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THE river portion of the Poughkeepsie Bridge is finished, the two ends of the last cantilever span having been connected August 30. A part of the viaduct which extends from the end of the bridge proper to the high land on the eastern side of the river is still to be built, but this involves no difficult work and can be done in a short time, if the material is at hand. From present appearances the bridge could be made ready for the passage of trains in October.

The railroad which is to form the main connection with the bridge on the western side of the Hudson is, however, still in an unfinished condition; there is much grading to be done, and track-laying has hardly been begun. It does not seem probable that trains will use the bridge regularly before the Spring of 1889.

CAR-BUILDING is becoming an important industry in the South, where only a few years ago there was but a single place—at Chattanooga—outside of the railroad shops, where cars were built, and that was only a small affair. The Baltimore *Manufacturers' Record* in a recent number published a long list of the shops in Virginia, Georgia, Alabama, and other States, with an account of the work which they are doing and the orders they are filling. It is only a year ago that one Southern shop—the Roanoke Works in Virginia—took from its Northern competitors a heavy order for a New England road, and others may be expected to follow, though at present all are busy on orders for Southern roads.

The Southern shops have the advantage of nearness to timber of the best quality, and most of them can also procure their iron with only charges for a short haul upon it; the cheapness of the iron supply is likely to increase also as the iron manufacture in the South is developed. It is probable that the Southern shops will be an element of growing importance in car manufacture, and that their competition will be felt more and more for several years to come.

THE control of the East Tennessee, Virginia & Georgia Railroad, which has for some time been held by the Richmond & West Point Terminal Company, will very probably be transferred to the Norfolk & Western Railroad Company in a short time, negotiations to that effect being now in progress. The East Tennessee line is a natural connection and continuation of the Norfolk & Western, and can be handled in connection with that road much better than with the Richmond & Danville, so that the transfer will probably benefit all parties to the agreement.

WORK is now well advanced on the change of the Toledo, St. Louis & Kansas City Railroad, nearly two-thirds of the main line from Toledo to East St. Louis having been altered from three feet to standard gauge, while the change of the entire line will probably be completed in October. The Cleveland & Canton Railroad will also be changed from three feet to standard gauge during October, the work being now in progress.

The change of these two roads marks the practical disappearance of the narrow gauge east of the Rocky Mountains, the only lines still of that gauge being a few short local roads scattered here and there, to most of which—as, for instance, those in the Catskill Mountain region—the break of gauge with their connections is of very small importance. The three-feet gauge which, according to the predictions of its advocates, was to supersede all the broader gauges, has thus proved an unsuccessful and somewhat costly experiment. Even the mountain lines in Colorado and Utah have decided to abandon it as soon as practicable.

ACCORDING to Russian authorities the new Transcaspian Railroad promises to be a good investment from a commercial as well as from a military point of view. The line is not only beginning to carry a large traffic heretofore left to caravans, but the ancient cities upon it have begun to increase their business, and to draw to themselves a considerable commerce. Moreover, preparations are being made to increase largely the productive capacity of the country along the line, much of which was in former ages cultivated by irrigation, and it is believed can again be made fertile in the same way. Chief among these undertakings is the restoration of the dyke of Sultan Bente on the Mourghab River, which was destroyed over 300 years ago. The waters of the Mourghab, which are now lost in the desert, were, when this dyke was in use, stored up, and served to irrigate an area of nearly 800,000 acres of land, which was once considered the most fertile part of Central Asia, but which has, since the water has been wasted, been practically a desert. The climate and soil are said to be especially adapted for the cultivation of cotton, and Russian engineers claim that with irrigation this district can be made to produce all the cotton required in their own country, with possibly a surplus for export, while the railroad will furnish means for transportation. Other similar and lesser schemes have been brought forward, and will probably be taken up as soon as the greater ones are well advanced.

It is also expected that with the completion of this road, and the opening of certain new highways, on which work

has been already begun, the Transcaspian line will in time become the great artery of commerce for Khorassan and all of Northern Persia.

ONE of the oldest engineering projects in the world is now gradually approaching completion, and the work will probably be finished during the coming year. This is the canal through the Isthmus of Corinth in Greece, which was first planned some 25 centuries ago, and on which work was actually begun under the Emperor Nero, so that over 1,700 years will have passed between its beginning and its final completion. As finally excavated the canal will be four miles long, with a depth of eight meters, or sufficient for the largest vessels which usually navigate the adjacent seas.

It was expected that the canal could be opened about the close of the present year, but the engineers have decided that to secure permanence, and to avoid continual obstructions and expensive dredging, it will be necessary to build retaining walls on a section about 1½ miles long, where the excavation is through a light sandy soil which cannot be made to form permanent banks.

The total cost of the canal will be about $9,000,000 or $4,000,000 more than the original estimate. Some doubt is expressed as to the possibility of levying sufficient tolls on the commerce which is likely to use the canal to pay interest on this cost.

The work, it is stated, has been very substantially done, and the cost of maintenance will probably be very light. It has been carried out under the direction of French engineers.

ARMY appropriations, after long dispute between the two Houses of Congress, have been finally settled by a conference committee, whose report covers both the Army Bill and the Fortification Bill. The provisions of the two bills were in a great measure interdependent, the Senate having largely amended one, and inserted appropriations which came from the House in the other. The ordinary appropriations for the maintenance of the Army are substantially the same as usual; the special appropriations over which the dispute arose are larger than provided in the House, but smaller than the Senate desired. These special appropriations include $200,000 for the manufacture of field guns and carriages; $250,000 for rifled mortars; $700,000 for the new gun factory at the Watervliet Arsenal; $1,500,000 for the purchase of rough-bored steel forging for guns; $500,000 for the purchase and test of guns by the Ordnance Board; $100,000 for testing pneumatic guns and shell, and $200,000 for tests and experiments of submarine mines and torpedoes. These appropriations, though not all that were asked for, will supply funds for a great deal of serviceable work during the coming year.

A PROPOSITION was made during the discussion of the Naval Bill in the United States Senate, to provide as an addition to the Navy a really formidable fighting ship of 15,000 tons displacement. Some Senators seemed to think that such a proposition was intended more as a joke than anything else, but while such a vessel would far exceed in size anything now under construction or heretofore proposed for our own Navy, it would really be not much larger than some owned by European nations. The Italian Government, which has always favored heavy ships, is now building one of 13,900 ton displacement, and a 15,000-ton vessel would be really very little larger. The policy of building such a warship may, however, be doubted, and several smaller vessels, which would cost about the same amount, would be of far greater use to us.

THE season of instruction at the Naval War College at Newport has arrived, and the sessions of the College have been resumed under direction of the Navy Department, although its work is somewhat limited by the failure of Congress to make specific appropriations for its support. The course of lectures this year on Naval Tactics, Coast Defenses, Strategy and National Law, will be very similar to that of last year, and will be doubtless equally beneficial to the naval officers who are permitted to attend. A proposition has been made in the Senate to establish the War College on a permanent basis, and to consolidate with it the School of Torpedo Instruction, which has been carried on at Newport for several years past. Another proposition has been made for the removal of the College to Annapolis, and its permanent establishment there as a department of the Naval Academy, but this does not seem to meet with much favor, and, indeed, Newport, or rather Shooter's Island, seems to be a place much better fitted for the purpose.

A CURIOUS controversy has arisen between the United States Light-House Board and the Trustees of the Brooklyn Bridge. The bridge roadway is lighted by a number of electric lights placed at intervals along the parapets, which serve their purpose very well, so far as the bridge is concerned, but which, it is claimed by the Light-House officials, are very confusing to the pilots of vessels navigating the East River. They say that the only lights which should be placed upon the bridge so as to be visible from the water should be the red and green signals which the law requires for all bridges over navigable waters. The Trustees, on the other hand, assert that the bridge lights are so far above the water that they cannot possibly interfere with navigation or deceive pilots, and, furthermore, that it is necessary to public safety that the bridge should be well lighted. As it is not a draw-bridge, and is high enough above the water to permit vessels to pass beneath the structure, they claim that as long as proper lights are shown on the piers no complaint can be made. The question is still unsettled, as the Trustees have positively declined to give way, and the Light-House Board has requested the United States District-Attorney to bring suit to enforce its orders.

It seems probable that this suit will be successful, and in that case the matter could very easily be arranged by shading or shielding the lights so that they would not be visible from the water below, and this would rather increase than diminish their efficiency so far as the lighting of the bridge roadway is concerned.

RAILROAD schools as such are not known in this country, and outside of the engineering departments, which are now largely recruited from the technical schools, no special preparation for railroad employment is required, those who are in it generally gaining their knowledge in actual, practical service. The article submitted by M. Bela Ambrosovics to the International Railroad Congress,

which is translated on another page, illustrates sharply two points of difference between our own and European railroads: the extent to which Government control is carried, and the preparation thought necessary for employés. In Hungary the State interests itself in the smallest details of management, and not only regulates the general administration of the lines, but also prescribes the manner in which the employés shall be appointed and the rules which govern their conduct. That it should also arrange a special course of study to prepare them for their work follows as a natural consequence, and the State railroad school is the logical outgrowth of State control from the European point of view.

The education of the civil and mechanical engineers of the railroads had already been provided for in the technical schools; and the railroad school which the Hungarian Government has established at Buda-Pesth is to train employés for the station service, the traffic department, and the general offices, fitting them to enter the lower ranks, and to be ready, when practical work has completed the education begun theoretically in the school, for promotion to the higher grades of the service. There can be no doubt that the idea is a good one, and that the employé will be better fitted for his work after going through the course; especially as it seems that the practical training is not to be neglected for the theoretical, but is to be an essential part of what is required of the man before a permanent position is secured to him.

One condition favoring the establishment of such a school, which exists in Europe, but is entirely lacking in this country, is the permanent nature of employment there. The young man who is appointed to a subordinate position at a station there looks forward to a lifetime to be spent in the work, and expects no change except the slow and gradual promotion which may come to him from time to time. He hopes to rise in the course of years, but has no idea of leaving the road voluntarily; he does not take it up as a temporary expedient, a "job," to be left as soon as something better offers, as his fellow-employé in this country wou'd do, and does do, and therefore he can afford to spend time in preliminary preparation which would here be considered as thrown away.

A second condition which would make the establishment of such a school difficult, if not impossible here, is the absence of any authority which could make the employment of its graduates compulsory, or even give them preference over others in appointments. The difficulty of securing concerted action of two or more companies in this direction would be another obstacle not easy to overcome.

That the establishment of such a school here is not to be expected, is, perhaps, one of the disadvantages inherent in our system of railroad management; whether this—and others which might be mentioned—are not more than counterbalanced by the advantages, is a question too broad for discussion here.

THE Indian Railroads last year were hardly as prosperous as usual, the Government statement showing a considerable falling off in business, with very little in expenses, so that there was not only a loss in the lines owned directly by the Government, but a considerable amount was also required to make up the dividends of the guaranteed companies. The decrease in earnings was largely due to the depressed state of the grain trade, which affected the receipts of the principal lines; but, nevertheless, it is stated that the total tonnage of merchandise carried was increased by over 1,000,000 tons; the ton-mileage is not given, so that it is probable the average haul decreased.

The total mileage operated at the end of the year was 14,583 miles, and there are now 2,000 miles more under construction or survey. The new lines built last year were not very great in length, and were chiefly in Northwestern India, although an important addition was made in the lower part of the country by the opening of the Southern Mahratta Railroad. Commercially, the most important lines opened in Northern India were several branches of the Northwestern Railroad, but the line which has attracted the most attention has been the military road to the Afghan frontier, which has been completed from Sibi to Kilia-Abdulla and up through the Bolan Pass, while work on its extension is in progress, and preparations have been made to begin the construction of the great Khojak Tunnel.

Some important improvements were made last year on the Indian lines, chiefly in the way of improving connections between the different roads and in substituting bridges for ferries. Prominent among these were the Kalpi Bridge over the Jumna, the Betwa Bridge, the Sukkur Bridge over the Indus, the Ferok Bridge on the Madras Railroad, the Balawali and Dufferin bridges on the Oudh & Rohilkhand Railroad. A good deal has been done in the way of substituting heavy steel rails and iron ties for the old iron rails on wooden ties on the South Indian and other roads.

While a large part of the work has been done by private or guaranteed companies, the Government has had two important military lines in hand, the Afghan frontier line, on which, judging from local comments, the progress made has been anything but satisfactory, and the extension of the Burmah State Railroad from Toungoo to Mandalay, which is now nearly completed, and on which some very rapid work has been done.

It is interesting to note that the narrow gauge is being gradually abandoned in India as well as in this country, and one of the events of the year was the changing of the Nagpur-Chattisgarh meter-gauge line, about 140 miles long, to the broad gauge.

LOCOMOTIVE BOILERS.

IT is understood very clearly now that a locomotive with an inefficient boiler is like a man with an unhealthy stomach, and that the source of power and speed in locomotives, as in human beings, is in their digestive organs. Locomotive builders and those in charge of the motive power of railroads have been slow to recognize the importance of sufficient boiler capacity, and for a long time the aim of the designers of these machines seemed to be to ascertain the minimum size of the steam-generator that would answer for the service in which they were to be employed. The attitude of mind in which such engineers seemed to entertain the question was apparently similar to that of inexperienced persons in relation to frictional bearing-surface. The natural man, who has never passed through a period of contrition for his shortcomings—which experience of hot bearings is sure to impose sooner or later—seems to abhor amplitude of bearing-surface. Hot boxes appear to be as essential to quicken the perceptions of young mechanics and engineers, with reference to

this subject, as the fires of sheol are to awaken the consciences of sinners generally. So with reference to boilers. The unregenerate mechanic seems to abhor large boilers. It is only when he has been through a sort of penitential experience with locomotives, when one of them gets out of steam in trying to pull a train up a heavy grade, and it utters what seems like a gasp, and, in the vernacular of the road, it "lays down" in despair, that he realizes their necessity. The endurance of a man, the speed of a horse, and the power of a locomotive all depend upon their breath holding out. Experience has thus finally taught those who have given due attention to the subject, that a sufficient supply of the breath of life in locomotives is dependent upon ample boiler capacity.

The question has then been asked, and last year was submitted to a committee of the Master Mechanics' Association, how big should a locomotive boiler be? The committee submitted their answer in a report to the last convention of the Association, and the rule given in that report for calculating the heating surface of a locomotive boiler for engines with cylinders of 24-in. stroke, was that *the area of one piston in square inches should be multiplied by* 5.8, *and the product would be the total heating surface in square feet.* At first sight it might appear as though this rule does not take due account of the size of the wheels, as, other things being equal, the diameter of the cylinders would be increased with that of the wheels. But the diameter of the wheels should be proportioned to the speed of the engine. Thus, suppose we have an engine with wheels 4 ft., and cylinders 18 in. in diameter, and that the wheels make 200 revolutions per minute. The area of such a piston would be 1.767 square feet, so that the spaces swept through by the two pistons, and, consequently, the quantity of steam used per minute, would be equal to $1.767 \times 2 \times 4 \times 200 = 2,827.2$ cubic feet. If an engine was built to run 50 per cent. faster, the diameter of its wheels and cylinders should be increased in like proportion, so that the area of its pistons should each be 2.65 square feet, and, therefore, if the engine ran the same number of revolutions per minute—which would mean 50 per cent. greater speed—it would consume 4,240 cubic feet of steam per minute. By the rule which has been given, the heating surface in the one case should be 1,476, and the other 2,214 square feet. But here we encounter a difficulty. If the two engines are of a similar plan, say of the eight-wheeled American type, with four driving wheels and a four-wheeled truck, it will be found that the running gear, cylinders, their connections, and the frames of the engine with the large wheels, must be all larger and heavier than those of the other engine, while at the same time the boiler of the one with the large wheels should be larger than that of the one with the small wheels. Let it be supposed that the weight of the engine with the small wheels is as follows:

Total weight	96,000 lbs.
Weight of boiler, with water and fuel	40,000 "
" " wheels, cylinders, frames, etc.	40,000 "
" " other parts	16,000 "

Now, if the size of the wheels and cylinders is increased 50 per cent., they will weigh 60,000 lbs., instead of 40,000. If this weight, added to that of the other parts, is deducted from the total weight, then there will be only 20,000 lbs. left for the weight of the boiler. That is, the boiler which should be the largest must weigh the least. In practice, slow-running engines have a larger proportion of their weight on the driving-wheels, which makes it essential that the cylinders should be larger, as is the case in ten-wheeled, Mogul, and consolidation engines, and fast-running locomotives have less weight on the driving-wheels, as in the case of the English machines with only one pair of driving-wheels, and thus the size of the cylinders is kept down, and, consequently, not so large a boiler is demanded.

It therefore seems as though the problem might be approached most advantageously from another side. Thus, supposing we determine from experience what class of engines is best suited for a given service. The weight of the rails will determine the load per wheel which may be carried, and it and the diameter of the wheels will decide what the size of the cylinders should be, which in turn will govern their weight and that of their connections. Having advanced this far, if we take their weight, and that of all the other parts, excepting the boiler and its attachments, and deduct it from the total weight of the engine, which has been determined by the load to be carried on each of the wheels and their number, the remainder will be the weight of the boiler. It is quite safe to say that within this weight the boiler cannot be made too large, and the problem therefore is, how to make the largest boiler of a given weight, and, of course, of the requisite strength.

Under these conditions, the only way to add to the weight and size of the boiler is to reduce the weight of the other parts. To this end it is desirable to keep the diameter of the wheels as small as possible, because with a given weight on them the size of cylinders and their connections is proportioned to that of the wheels, and therefore if all these parts are small and light the boiler may be larger and heavier, and yet keep the total weight of the engine within the prescribed limits. In designing locomotives, then, it would seem that there is a decided advantage in keeping the weight of all the parts not connected with the boiler as small and light as is practicable, so that the dimensions of the latter may be increased. It is also desirable that the lightest form of construction for boilers should be adopted, so that they may be of the maximum size and capacity. Forms of construction which require the use of heavy braces and stays should be ignored, and the preference given to plans which will make a boiler of the maximum size and strength, and the minimum weight. The maxim is undoubtedly true that "within the limits of weight and space to which a locomotive boiler is necessarily confined, it cannot be too large." This being true, it would seem to be worth while in building locomotives to give especial care to the designs of all the parts which do not form a part of the boiler, and are not attached to it, with a view to reducing their weight, because every pound taken from these parts may be added to the boiler.

With the increase of the size of locomotives another difficulty is encountered. The gauge of the rails is fixed, and, consequently, the distance between the frames—if they are placed inside of the wheels, and are of the usual form employed on American locomotives—is limited to about 42 or 44 inches. When the barrel of the boiler is made from 60 to 70 inches in diameter, the fire-box is relatively very much contracted, and the back view of such a structure reminds one of a broad-shouldered woman who is tightly laced. Under these conditions, both her vitals and those of the locomotive are unduly and injuriously

contracted. To put the fire-box above the frames, and thus get from six to eight inches additional width, is open to some objections, although these are, perhaps, counterbalanced by the advantages gained. To put it above the wheels is open to still greater objections.

The problem then presents itself, how to get a wider fire-box for the large engines which are demanded by the traffic of the time than is possible with the present plans of construction. This problem is daily becoming more urgent, and a solution of it would be an improvement in locomotive construction which is urgently demanded.

The Sewerage of Cities.

IN the article on this subject, the concluding chapter of which was published in our September number, M. Mayer, a distinguished French engineer, although speaking exclusively of matters in his own country, curiously illustrates the existing state of affairs in this country, and his remarks are quite as applicable here as to those for whom they were especially written. The great importance of a systematic treatment of the subject has not been and is not at all realized among us, for while it is generally admitted that sewers are needed, the question has usually been allowed to go by default, as it were, and very few attempts have been made at a thorough consideration of this subject, which is next to that of the water supply in its effect on the public health.

We do not mean by this to depreciate the value of the work which has been done in this country by Waring, Shone, and other prominent engineers, or the less conspicuous but faithful work which has been done in many places by conscientious engineers who have worked hard to do their duty in face of a very discouraging public indifference on the subject.

The trouble always has been the lack of thorough study. In the majority of cases the sewers of a town or village are begun without any careful consideration of the subject, and as the town grows additions to the system are put in here and there as needed at haphazard, with no general plan, and often without any calculation for the present or for the future. It is the exception rather than the rule to find in our smaller towns any general collecting sewer, and not only there, but in many large cities instances can be multiplied where a 24 in. discharges into an 18-in. pipe, and other blunders of the same kind have been made.

Even where some attempt has been made at proper planning and arrangement, there has been no disposition to keep in view the true object of a system of sewers, which is, as M. Mayer says, to carry off foul water alone, the solid refuse, or garbage as we call it, being left to be disposed of in a different way. Then, too, the rain-water to be disposed of is too often merely guessed at, or perhaps not considered at all, and even when some rough allowance is made for it, no attempt is made to estimate the quantity which must be provided for or to consider the nature of the ground, the kind of street pavements, and many other matters which must be taken into account.

Especial attention might be paid to what M. Mayer says in relation to land drainage, and too much emphasis cannot be put upon the fact that the drainage of low ground is not one of the proper functions of city sewers, and should be provided for by a separate system, the cost of which should be borne entirely by the property benefited, and should be regulated by local circumstances. As a rule in this country, where there is an abundant opportunity for the selection of proper sites for towns, low swampy ground is not taken in the first place, and where the growth of the city makes it expedient to take in such ground, the profit accruing to the owners is usually quite sufficient to enable them to bear without hardship the cost of such special works as may be needed.

One important matter, which has as yet received no consideration whatever here, is the disposal of sewage, a problem which increases in difficulty very rapidly with the growth of a town, and which, as a rule, cannot be treated in a general way, but must be in each case made a special study. Our habit has been to meet this case in the easiest possible way, and this has too often resulted in simply discharging the refuse of a city into the nearest river, allowing it to pollute the water and to become a danger and a nuisance to other towns. We have not yet begun to realize what can be and should be done in this direction, and no serious attempt has been made to utilize city waste, even in the more densely populated portions of the country.

It is well to bear carefully in mind the general principles laid down for designing a system of sewers, either for a large or for a small town, and the many factors which come into the case—the nature of the ground, the surface, the fall to be obtained, the kind of houses, the proportion of the surface occupied by buildings, and many other matters. A district, for instance, occupied by a purely resident population needs very different facilities from one where there are many factories, just as one covered by the small houses and gardens of a rural city presents conditions widely different from one inhabited by a dense tenement population, as in such cities as New York and Boston. In the case of the smaller cities, to which these articles are especially applicable, the nature of the water supply must always be carefully considered, its quantity, the head of water, and the force of current which can be used. It is hardly necessary here, where every town expects in the future to be the leading one of its State, to caution engineers to make allowance for future growth.

One of the most difficult of the questions which usually confront an engineer in this country is the financial one. It might be said that this does not properly fall within his province, but it is nevertheless true that he is obliged to consider it. He must remember that in planning a system of works which is to be paid for by the people, it will be necessary to make one which is worth what it costs, and which so far as possible presents a value which can be estimated in money by those who pay for it. He must consider the ability to pay, and must not, in estimating the value which proper sewerage will add to property, make it cost so much as to impoverish the present owners. He must also remember that the increment of value in property cannot always be expressed in money, and that the advantage to public health is sometimes very difficult to put down in dollars and cents. A reduction in the death-rate of a city is excellent, but not always a thing which can be credited on a ledger.

The true value of sanitary work is, perhaps, one of the hardest things to express definitely; it has been claimed that the only true test is the difference in rental value of property before and after sanitary work is undertaken, but even this is often an unreliable guide.

The manner in which such works are to be paid for is another question which falls outside the engineer's prov-

ince, but which nevertheless very often affects the limits placed upon his work; and it may frequently happen that he will be consulted in the matter. Of course no general rule can be laid down in such cases beyond making the suggestion that it is perfectly fair to put upon posterity, in part at least, the burden of any works which will probably benefit them more than the present generation. The only general principle which can be laid down is to insist upon the closest economy which is consistent with good and thorough work. Fortunately, it is hardly necessary to remind the present generation of engineers that such economy is only consistent with the strictest professional integrity.

NEW PUBLICATIONS.

NAVAL RESERVES, TRAINING AND MATÉRIEL: NAVAL INTELLIGENCE, GENERAL INFORMATION SERIES, NO. VII., JUNE, 1888. ISSUED FROM THE OFFICE OF NAVAL INTELLIGENCE, BUREAU OF NAVIGATION, NAVY DEPARTMENT. Washington; Government Printing Office.

The title given to the present number of *Naval Intelligence* is taken from the leading paper, which is on Naval Reserves and Coast Defense, and is by Lieutenant J. C. Colwell, U. S. N. This paper starts with a brief statement of the extraordinary fact that the United States is the only maritime nation in the world which makes no provision whatever for a reserve force for its Navy, or for the speedy recruiting of its naval force, even to fill up its ordinary quota in time of peace. This statement is further emphasized by a careful account of the provisions made in England, France, Germany and elsewhere for the establishment and thorough organization of a reserve force both of officers and men. The English Naval Reserve has been in existence under various forms for nearly 90 years, having been first formally organized in 1798, and at present has a nominal strength of 920 officers and about 30,000 men, or an actual strength of somewhat over 19,000 actually enrolled; this reserve force alone being 2½ times greater than the entire authorized number of our own Navy. In addition to this there is a further force, which might be effectively used in case of war, consisting of officers on the retired list, coast-guards and others, who could be called upon in case of necessity, and who would be very effective in manning vessels for coast and harbor defense.

In France the reserve system goes much further, the entire male population of the sea-coast districts being enrolled in the *Inscription Maritime*, which includes all fishermen, boatmen, and seamen not only of the coast but on the rivers, to the head of tide-water. These men are included in the enrollment from the age of 18 up to 50, and are liable to be called out for active service at any time; moreover, from the *Inscription Maritime* the active force of the Navy is recruited, such number as may be required—from 2,000 to 2,500 yearly—of the younger men being drawn for service in the same manner as conscripts are drawn for the Army. The term of service of these conscripts in the Navy is seven years, and two years of this term in time of peace are usually passed in the Reserve. The Reserve is divided into two classes: the men of the first class or Active Reserve being liable to a call at any moment; they serve in this class for four years and then pass into the second class, which is only liable to be called upon in time of war or great emergencies. Under the regulations provided a certain exemption is made to pilots, masters of vessels, seamen employed on ships engaged in foreign trade, and men with families. The total number of men included in the *Inscription Maritime* is about 160,000; the number of men in the actual service of the Navy is somewhat over 30,000 usually. It is estimated that nearly one-third of the total enrollment would be available for service. A portion of this reserve, moreover, is drilled and trained yearly in the use of heavy artillery, and could at once be employed in sea-coast forts as well as on shipboard.

The German Naval Reserve is organized with the same thoroughness as the Army of that country, to which its administration corresponds very closely. As in France, it includes all seafaring men, and, in fact, a large portion of the sea-coast population. The liability to service in that population is the same as that required for the Army in the inland districts, and every man is obliged to serve some time either as conscript or volunteer in the active naval force. If not required for active service he is enrolled in the Active Reserve, in which he remains for 12 years; at the end of that time those who have completed the required terms, either of active service or training, pass into the *Seewehr*, which corresponds with the *Landwehr* of the Army, and while in that class are liable to be called out at any time. The *Seewehr* has a completely organized force of officers and men, all of whom are called out periodically for training and exercise, and would in case of emergency constitute an exceedingly effective addition to the Navy, ready to man a large number of additional vessels, while, as in France, a sufficient number are trained in the use of heavy artillery to serve in the sea-coast fortifications. After completing their service in the *Seewehr*, the officers and men pass into a third class or reserve, which corresponds to the *Landsturm* of the Army. Lieutenant Colwell's paper also gives accounts of the naval reserves of Russia, Austria, Italy, Spain, Sweden, Holland, Denmark, Portugal, Greece, and Turkey, nearly all being organized on the German system. Japan also has a very excellent system of naval reserves, both officers and men.

A reserve force of officers and seamen is evidently useless unless there are vessels on which they can be employed, and accordingly nearly all the European nations, following the lead of England and France, have adopted systems under which a considerable number of ships employed in mercantile voyages can be taken for war purposes in case of necessity. In England there are fixed rates of charter provided by law, while in France and Italy navigation and construction bounties are paid for all vessels coming up to the requirements of the naval authorities, and in return it is provided that they can be taken for use by the Government in case of emergency. In Russia and Germany all vessels owned are liable to be taken for Government use whenever required, and similar provisions are made in many other countries. In the United States, as is well known, while the question of naval reserves has been much discussed, nothing has been done, and in case any addition to the naval force should be required in a hurry we would have to depend, as in 1861, on the purchase of such vessels as might be picked up by the Government, and on voluntary enlistments.

The second paper in this issue, by Lieutenant S. A. Staunton, is on Naval Training, and gives especial attention to the changes made in foreign navies in the training

of both officers and men, recent progress in ship construction, and in the implements of naval warfare. A third and carefully illustrated paper, by Lieutenant C. E. Vreeland, is on Target Practice Afloat, both in our own and foreign navies. Lieutenant W. H. Beehler gives an account of the manœuvres of the English, French, and Italian navies during the season of 1887, and also a brief account of the manœuvres of the North Atlantic Squadron in the neighborhood of Newport last fall. There are also illustrated articles on Electricity on Shipboard, by Lieutenant J. B. Murdock, and on Marine Boilers, by Passed Assistant Engineer R. F. Griffin; with shorter articles on the Preservation of the Bottoms of Iron Ships, by Lieutenant Seaton Schroeder, and on the Transportation of Torpedo Boats by Railroad, by Lieutenants W. I. Chambers and A. Sharp.

The longer articles are supplemented, as in the case of former issues of *Naval Intelligence*, by a number of interesting and valuable notes on naval affairs in the United States and abroad. Some extracts from these in relation to our own Navy will be found on another page.

KRUPP AND DE BANGE: BY E. MONTHAYE, CAPTAIN IN THE BELGIAN GENERAL STAFF. TRANSLATED, WITH AN APPENDIX, BY O. E. MICHAELIS, CAPTAIN OF ORDNANCE, UNITED STATES ARMY. New York; issued by Thomas Prosser & Son, No. 15 Gold Street.

The best known system of modern gun construction is that originated by Herr Krupp, which has been adopted in Germany and other European countries, for which the originator built a great number of guns at his Essen Works. More recently a new system, that of De Bange, which had been adopted in France, has attracted much attention, and an animated discussion is going on in military circles over the comparative merits of the two systems. The present work, which is intended to give a complete account and comparison of the two, is written by an officer of the Belgian Army, who has had, owing to the peculiar neutral political position of his country, special opportunities for studying the practice of other armies. His conclusions, although he has evidently tried to keep an impartial frame of mind, are almost entirely in favor of the Krupp system, and his arguments are supported by a formidable array of facts and statistics. The book is just now of practical interest in this country, as the new experimental high-power guns on which our Army and Navy departments are engaged are of a modified De Bange model.

Captain Michaelis, who has made a special study of the construction and material for heavy ordnance for a number of years past, is especially fitted for the translation and adaptation of this book to our own practice.

The contents of the book include three parts and an appendix. The first part consists of a chapter on Gun Metal, the various kinds used, and their properties; a chapter on Gun Construction, giving an account of the methods adopted in the two systems; a chapter on Ballistic Performance, and one on the results attained by the Krupp system in various European states. The second part consists of the arguments and objections raised by the adherents of the Krupp system against the new guns, and gives a description of the two systems of manufacture, concluding with an account of the Belgrade competition of heavy guns, about which so much has been said and written abroad.

The third part is given up to a description of the Krupp Works, and their methods of manufacture, while the appendix is devoted to a defense of the Krupp system of artillery, and some accounts of the failure of different guns in practice.

The book, although it has, as we have said, an evident leaning toward the Krupp system, gives a very fair account of its opponent, and contains much that is valuable and worth study by those who are interested in this subject.

MANUAL OF THE RAILROADS OF THE UNITED STATES FOR 1888: SHOWING THEIR ROUTES AND MILEAGE; STOCKS, BONDS, DEBTS, COST, TRAFFIC, EARNINGS, EXPENSES AND DIVIDENDS; THEIR ORGANIZATION, DIRECTORS, OFFICERS, ETC.: BY HENRY V. POOR. New York; published by H. V. & H. W. Poor, No. 70 Wall Street.

Poor's Manual has been for so many years the only available source of information concerning our railroads, that it has grown to be indispensable to all who have occasion to use railroad statistics.

It is a curious illustration of the absence of Governmental regulation of railroads in this country, that the only publication which can be referred to, or which can pretend to give an account of all the railroads in the country, is purely a private enterprise, and depends for its facts and figures in great part upon the reports and documents furnished voluntarily by the companies. This state of affairs may be done away with to some extent when the system of reports called for by the Interstate Commerce Commission comes into full operation, but the fact remains that we always have been, and up to the present time, are still dependent on private parties for such figures as we possess in relation to our whole railroad system.

It is due, however, to the publishers of the *Manual* to say that their enterprise has always been conducted with much care and impartiality, so that the book is as reliable as any publication of the kind could well be, without official authority. It cannot be claimed, of course, that it is perfect, or that there is not some opportunity for improvement in details, but the *Manual* has gone far to make up for the absence of official returns.

The summary of railroad business given in the introduction is deprived of part of the value it might have by the variation in the periods covered by the individual reports on which it is based, but it gives as close an approximation to the total as is attainable under present circumstances.

ABOUT BOOKS AND PERIODICALS.

THE MAGAZINE OF AMERICAN HISTORY for September, in a very interesting article on the Centennial Celebration of the Settlement of Ohio at Marietta, has a long account of Colonel Rufus Putnam, who was the most distinguished engineer of the Revolutionary period, and may fairly be styled the Father of American Engineers. Colonel Putnam was the chief engineering officer of the Revolutionary Army. He surveyed and laid out the first purchase of the Ohio Company in the Northwestern Territory, and led the first company of settlers in that territory. He was responsible for the first organization of the public survey of the national territory, and originated the system of laying out townships, which has been in use up to the present day in all Government lands.

In the same number there is reprinted a very curious article from the London *Universal Magazine* for July,

1757, describing the River Ohio, which, in spite of many geographical errors, contains a clear prediction of the future importance of Fort Du Quesne (now Pittsburgh) as a center of commerce for all the Ohio and Mississippi valleys, and also as a great manufacturing point. The writer, whose name is not given, evidently had a clear perception of the natural advantages of the place, though his knowledge of the lower Ohio was rather indefinite.

The leading article in the JOURNAL OF THE MILITARY SERVICE INSTITUTION for September is a long and exhaustive one on Material for Field Artillery for the United States Army, by First Lieutenant A. D. Schenck, Second Artillery ; Lieutenant-Colonel Henry M. Lazelle, Twenty-third Infantry, contributes an article on India, the result of his observations on a trip made under orders from the War Department to witness the maneuvers of the army of that country in the winter of 1885–86. There are interesting shorter articles by Lieutenant-Colonel H. Clay Wood, Captain Edward Hunter, and Captain James H. Haynie, and the conclusion of the discussion by the Institution of Lieutenant Weaver's paper on Armament of the Outside Line.

In HARPER'S MAGAZINE for September, Charles Dudley Warner's Sketches of the Great West are continued by somewhat rose-colored descriptions of Memphis and Little Rock. His statements of the growing commercial importance of Memphis as a center of both railroad and river traffic are true ; the account of the peculiar municipal condition of the city is interesting, but the experiment must still be regarded as a very doubtful one.

In the October number Mr. Warner talks—for his papers are more familiar talks than formal articles—of St. Louis and Kansas City.

In SCRIBNER'S MAGAZINE for October appears an article on the Railroad in its Business Relations, by Professor Arthur T. Hadley, which treats of the questions of rates, pooling, and Government control. While Professor Hadley is not a railroad man himself, he is well known as a careful student of railroad questions ; his lectures in Yale College have earned him a high reputation, and he is well qualified to write on those points which he has taken up.

LIGHT, HEAT, AND POWER, the well-known gas journal published in Philadelphia, opens its fifth volume by changing from a semi-monthly to a weekly form. It is an excellent journal for those interested in this subject, and this evidence of its increasing prosperity is gratifying.

BOOKS RECEIVED.

INSTITUTION OF MECHANICAL ENGINEERS : PROCEEDINGS, MAY, 1888. London, England ; published by the Institution.

JOURNAL OF THE IRON AND STEEL INSTITUTE : NO. 1, 1888. London ; issued for the Institute by E. & F. N. Spon.

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England ; published by the Institution. The present installment of these papers includes the Tay Viaduct, Dundee, by Crawford Barlow ; the Construction of the Tay Viaduct, by William Inglis (with abstract of discussion) ; Effect of Temperature on the Strength of Railway Axles, Part II by Thomas Andrews ; the Prevention and the Extinction of Fires, by Alfred Chatterton ; a New Method of Investigation Applied to the Action of Steam-Engine Governors, by Professor V. Dwelshauvers-Dery ; the Distribution of Hydraulic Power in London, by Edward B. Ellington.

SCARRITT CAR CHAIRS AND FORNEY SEATS AND CAR FURNITURE : CATALOGUE. Issued by the Scarritt Furniture Company, No. 414 North Fourth Street, St. Louis, Mo.

WATER-SUPPLY IN THE WHOLESALE DISTRICT OF THE CITY OF ST. PAUL, 1888 : REPORT MADE TO THE CITY COUNCIL OF ST. PAUL, MINN., BY JOHN W. HILL, CONSULTING ENGINEER. St. Paul, Minn. ; published by the Council.

THE OTTAWA NATURALIST : TRANSACTIONS OF THE OTTAWA FIELD NATURALISTS' CLUB FOR THE QUARTER ENDING AUGUST, 1888. Ottawa, Canada ; published by the Club.

JOURNAL OF THE NEW ENGLAND WATER-WORKS ASSOCIATION : PROFESSOR GEORGE F. SWAIN AND WALTER H. RICHARDS, EDITORS. New London, Ct. ; issued from the Junior Editor's office. The present number contains the proceedings of the Seventh Annual Convention of the Association, which was held in Providence, R. I., June 13, 14, and 15, with all papers read at that meeting and the discussions thereon.

PROCEEDINGS OF THE MICHIGAN ENGINEERING SOCIETY AT THE NINTH ANNUAL CONVENTION, HELD IN KALAMAZOO, MICH., JANUARY 17-20, 1888. Climax, Mich. ; published by F. Hodgman, Secretary.

AIR-COMPRESSORS, ROCK DRILLS, ETC. : CATALOGUE NO. VI OF THE CLAYTON AIR-COMPRESSOR WORKS. New York ; No. 43 Dey Street.

THE PHILOSOPHY AND PRACTICE OF MORSE TELEGRAPHY : BY T. JARRARD SMITH. New York ; issued by E. S. Greeley & Co., 5 & 7 Dey Street.

THE CRIST VIBRATORY ENGINE : CATALOGUE. New York ; issued by the Crist Engine Company.

SELF-WINDING CLOCKS UNDER THE POND PATENTS : CATALOGUE. New York ; issued by the American Manufacturing & Supply Company, No. 10 Dey Street.

GAS. REPORT OF THE JOINT COMMITTEE OF THE CITY COUNCIL AND BOARD OF TRADE OF AKRON, O., ON ILLUMINATING AND FUEL GAS ADAPTED TO HOUSEHOLD, MANUFACTURING, AND INDUSTRIAL USES. New York ; issued by T. William Harris & Co., Engineers and Contractors, No. 44 Broadway.

HIGH-SPEED CORLISS STEAM-ENGINES : CATALOGUE. Elmira, N. Y. ; B. W. Payne & Sons.

THE BLACKMAN AIR-PROPELLER FOR DRYING : CATALOGUE AND DESCRIPTION. New York ; Howard & Morse, No. 45 Fulton Street. UNIVERSAL MILLING MACHINES : CATALOGUE AND DESCRIPTION. Philadelphia ; Pedrick & Ayer, No. 1025 Hamilton Street.

ALLEGHENY COUNTY : ITS EARLY HISTORY AND SUBSEQUENT DEVELOPMENT : PUBLISHED UNDER THE AUSPICES OF THE ALLEGHENY COUNTY CENTENNIAL COMMITTEE. Pittsburgh, Pa. ; published by Snowden & Peterson. This is the official programme of the centennial celebration of the settlement of Allegheny County, Pa., and contains a history of the county, with notices of its leading industrial establishments.

THE PRINCIPLES OF RAILROAD LOCATION.

BY PROFESSOR C. D. JAMESON.

(*Continued from page 398.*)

CHAPTER XXXII.

RACK-RAILROADS.

THE next method used in surmounting great elevations, where ordinary development or the use of switch-backs is impossible either on account of the cost of construction or topographical features, is by means of RACK-RAILROADS.

In the ordinary railroad the driving-wheel of the locomotive and the rail have each a smooth surface where they come in contact, and the tractive power is due simply to the adhesion between these two smooth surfaces. As has been stated, this adhesion varies with the state of the rail and the wheel, whether moist or dry, etc., and also directly as the weight on the drivers; but it may be taken generally as one-quarter the weight on the drivers. From the resistance due to grade and that opposed to the movement of a train upon a straight and level track, we can at once see that a rate of grade which gives a very slight vertical angle will soon consume all the tractive power of the locomotive. That is, the resistance opposed to the motion of a train upon a grade soon becomes equal to or greater than the adhesion between the rail and the driver.

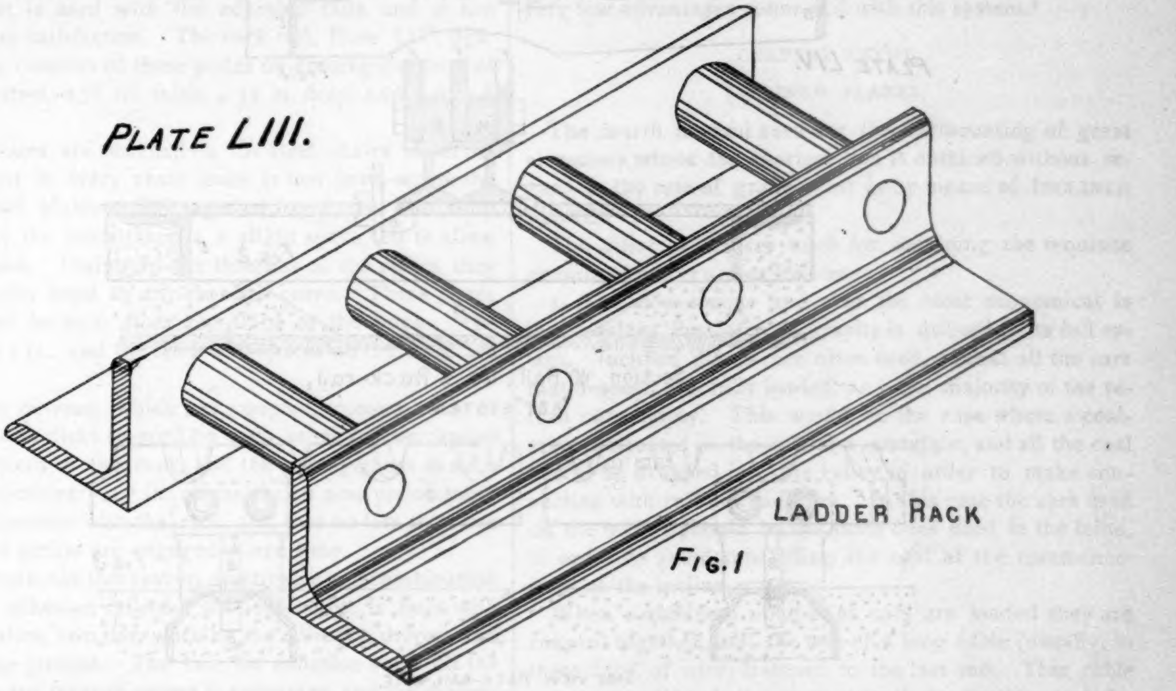
Where circumstances are such that a grade is required so steep that this adhesion between the smooth rail and the driver is insufficient, then there is introduced a rack-rail, as shown in Plate LIII, fig. 1, and Plate LIV, figs. 3 and 4, or a toothed rail, on which runs a pinion or driving-wheel having similar teeth, which engage the teeth on the rack.

By this arrangement the tractive power is not in any way dependent upon the adhesion between the rail and the wheel, but simply upon the steam-generating and cylinder power of the engine. No matter how much power may be exerted, the drivers cannot turn without either a backward or forward motion of the engine. In other words, the drivers cannot slip.

There are various systems of rack-railroads, but they all depend upon this one principle, that the power acts in such a way upon the rail by means of cogs or teeth, as to remove all possibility of slipping.

The most general form is to have the rack-rail a third rail between the two smooth rails upon which the cars run. In this case the toothed drivers on the locomotive are placed in the center one behind the other. Where the grade is very steep, in order to guard against all chances of an accident from a runaway train, there is often a mechanical device so arranged that if the brakes do not act, or if the rack-rail or driver breaks, the whole train can be lifted bodily from the track, resting simply upon shoes, which make it impossible for it to descend.

PLATE LIII.



LADDER RACK

FIG. 1

Owing to the fact that rack-railroads require engines of special construction that are not in any way suited for high speed over ordinary tracks, these roads are not usually made parts of any long line of road, but should be, and in most cases are, simply small independent lines of merely local importance.

Owing to their construction they are not adapted to high speed or to a large business. The first and up to within a few years the only railroad on the rack system in this country was the Mount Washington Railroad, designed and built by Sylvester Marsh.

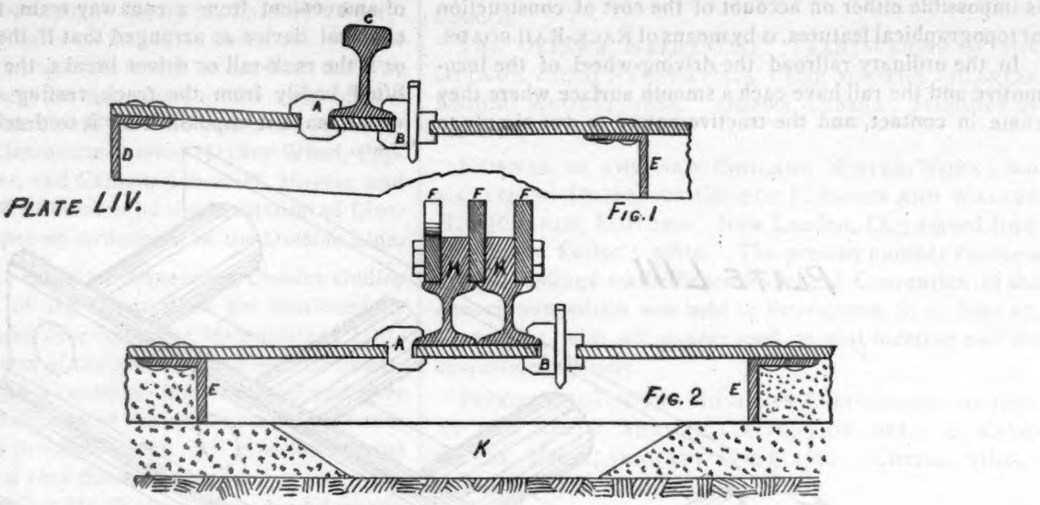
This system, with some few alterations, was afterward introduced into Europe by Riggenbach, and has since become known as the "Riggenbach System," although, as Riggenbach was well acquainted with Marsh's railroad, and made no changes in the principle, all the credit should be given to Marsh, and not to Riggenbach.

A more modern example of a rack-railroad built upon exactly the same principle as the Mount Washington Railroad is the Green Mountain Railroad at Mount Desert, Me. The length of this road is 6,300 ft., and its rise 1,254 ft. It is made up of a succession of steep grades, with intermediate pieces of easier grades. The maximum

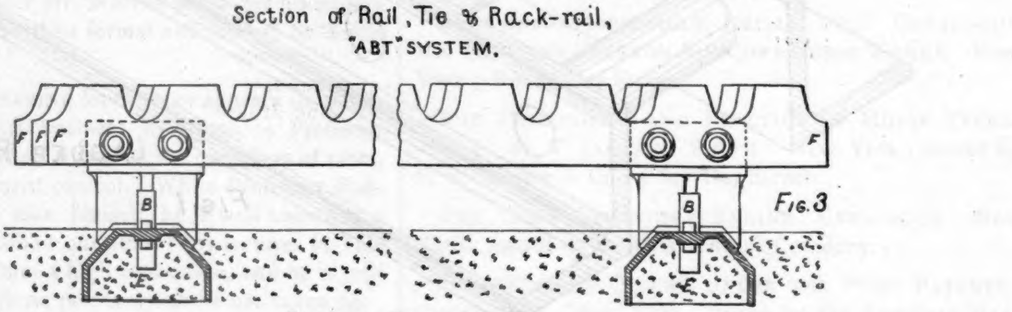
grade is 33⅓ per cent., and the minimum 5 per cent. There is only one curve of 1,910 ft. radius.

The radical difference between this road and the Mount Washington is that the latter is built almost entirely upon trestles, while that at Mount Desert is built upon solid rock or timber cribbing. The rack-rail is of the ladder type, built of angle-irons, as shown in Plate LII, fig. 1. Owing to the steep grade, and the great purchase needed for the driving-gear, the track is built as follows: Where the stringers were laid directly on the natural ledge, this ledge was cleared and leveled; then 1½-in. holes were drilled every 6 ft. and iron bolts driven through the timber stringers and into these holes. When the stringer came above the ledge bed-ties were introduced under them every 6 ft., these ties being held in place by bolts driven into the ledge on the down grade side of the ties. On top of the stringers are the rail-ties, 6 in. × 6 in. × 6 ft. long, held in place by ⅞-in. bolts driven into the stringer through a groove on the down grade side of the tie. The adhesion rails are of the ordinary T-type, weighing 49 lbs. per yard, and held in place by two ordinary spikes in each tie.

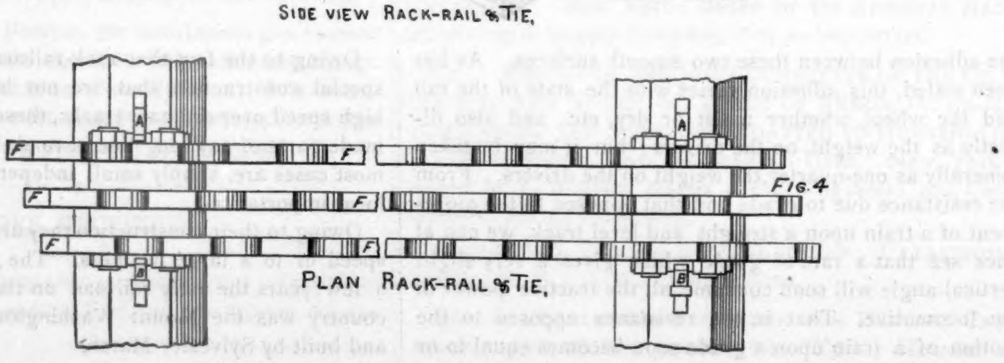
The rack is built, as shown in Plate LIII, of two angle-irons, 3 in. × 3 in., placed 4 in. apart in the clear, with 1½-in. round bars, shouldered and riveted between them.



Section of Rail, Tie & Rack-rail, "ABT" SYSTEM.



SIDE VIEW RACK-RAIL & TIE.



PLAN RACK-RAIL & TIE.

The pitch is 4 in. The rack is made in sections 12 ft. long, and held in place by 5½ in. lag-screws, 14 to each section. From this description it will be seen that in no possible way can the track slip down hill.

The rack-rail is placed midway between the smooth rails, and is acted on by a pinion on the locomotive.

The advantage of this road is simply the possibility of introducing grades of almost any degree of steepness, and thus reducing the cost of construction and the length of the lines. The disadvantages, however, are many. Owing to the construction, the speed is limited to about 3½ to 4 miles per hour, and the locomotive cannot be run on an ordinary railroad by adhesion. This limits their use to locations where the rack system can be used entirely.

Another disadvantage is that, owing to the construction of the locomotive and the rack-rail, the introduction of any curves sharper than 3° or 4° is very objectionable.

The system of rack-railroad that up to the present time has given the greatest satisfaction as an operating road, is that invented by Roman Abt, formerly Chief Engineer of the Riggenbach Works in Aarau.

The best examples we have of this system in actual work are the railroad from Blankenburg to Tanna, in the Harz, and the freight road to Oertelsbruch, in Thuringia.

These are combination roads of the adhesion and Abt system. And therein lies the great advantage of that system over all others, that it works perfectly in combination with the ordinary adhesion principle, using the same locomotive for an entire combination line, and only using the rack and pinion where necessary.

The permanent way on these lines is built as follows: The rails are of steel, and of the section shown in Plate LIV, fig. 1; they weigh 60.2 lbs. per yard, and are fastened on iron ties of the Vautherin type by iron keys *A B*, as shown in the drawing. The particular feature in these ties is the two cross-ribs, *E E*, on the inside of the tie, which add so much to its stiffness, and the stability of the road-bed.

The rail-joints come between the ties; the ties are spaced 34.64 in. from center to center. The rack-rail is fastened to the center of the ties by the same system of keying that is used with the adhesion rails, and it has given entire satisfaction. The rack-rail, Plate LIV, figs. 2, 3, and 4, consists of three plates or rectangular bars of Bessemer steel, 0.78 in. thick, 4.33 in. deep, and 8 ft. 7.8 in. long.

These plates are fastened in the steel chairs in such a manner that in every chair there is one joint where the ends of two plates come together, and also two solid plates. At the joints there is a slight space left to allow for expansion. Owing to the thinness of the plates, they can be readily fitted to any required curve. These plates are stepped by each other one-third of the pitch. The pitch is 4.72 in., and the teeth and spaces on the rack are equal.

The two pinions, which are coupled, consist each of three separate disks stepped by each other to correspond with the teeth in the rack, and the arrangement is such that for about every 0.7 in. on the rack a new pinion tooth comes in contact with the rack, and that no less than five teeth of the pinion are engaged at one time.

In order to make this system practicable as a combination rack and adhesion railroad, the locomotive is built with four cylinders, two for working the adhesion drivers and two for the pinions. The two for adhesion work all the time when any tractive power is necessary, and the pinions only to supply the amount of power needed at times in excess of that derived from adhesion.

The rack-rail is only laid, of course, in those parts of the line where it is needed, and where it begins the end is rounded off so as to enable the pinion to mount it and become engaged.

A short section of the rack at each end is connected to the main portion not by a rigid joint, but by a hinge that allows it to move vertically. This portion is supported on springs, and if, when mounted by the pinion, the teeth do not engage, the rack is depressed until the pinion strikes a base plate laid at the height of the bottom of the spaces in the rack. Upon this plate the pinion runs upon its outside circumference, which is greater than the one on which it runs when the teeth are engaged. Consequently, it gains upon the rack, and in a very short distance it has moved ahead enough for the teeth to engage.

By this means all danger of breaking either rack or pinion when passing from an adhesion to a rack section is obviated, and there is no time lost.

Another point to which attention should be called is the manner of putting up the track in regard to the ballast. All the heavy tamping is done under each of the adhesion rails, while no ballast or tamping is put under the tie in the center, this part being left entirely without support, and the ballast on each side forming a ditch.

The object of this lack of support in the center is to allow for any settling of the adhesion rails, and do away with all possibility of springing the tie in any way, and thus changing the relative heights of the rack and adhesion rails.

In both the Abt system and in the old ladder-rack the locomotives are so constructed that when the trains descend with the steam shut off, air is admitted to the cylinders that drive the pinions and makes them serve as air brakes, or, to use a more explicit term, as speed governors.

There is one rack-railroad built where the pinions are placed in a horizontal position with the rack vertical, but it has not proved a success in operation, and there are very few advantages connected with this system.*

CHAPTER XXXIII.

INCLINED PLANES.

The fourth method used for the surmounting of great elevations where the shortest line is obtained without regard to the rate of grade used is by means of INCLINED PLANES.

The different devices used for obtaining the requisite amount of power are as follows:

1. The most simple and also the most economical is that wherein the force of gravity is utilized to its full extent. Inclined planes are often used, so that all the cars that descend are fully loaded, and the majority of the return cars empty. This would be the case where a coal-mine is situated on the side of a mountain, and all the coal had to be dropped into the valley in order to make connection with railroad facilities. In this case the cars used on the incline should be the same ones used in the mine, in order to avoid rehandling the coal at the commencement of the incline.

When a sufficient number of cars are loaded they are coupled together, and the end of a long cable (usually, in these days, of wire) fastened to the last one. This cable passes around a drum at the top of the incline, and the other end is fastened to a train of empty or only partially loaded cars at the foot of the incline. Then, when the loaded cars are started down, their weight pulls up the empties. The speed at which they run is regulated by the drum, the motion of which is controlled by a friction-brake. In this case the force of gravity does all the work.

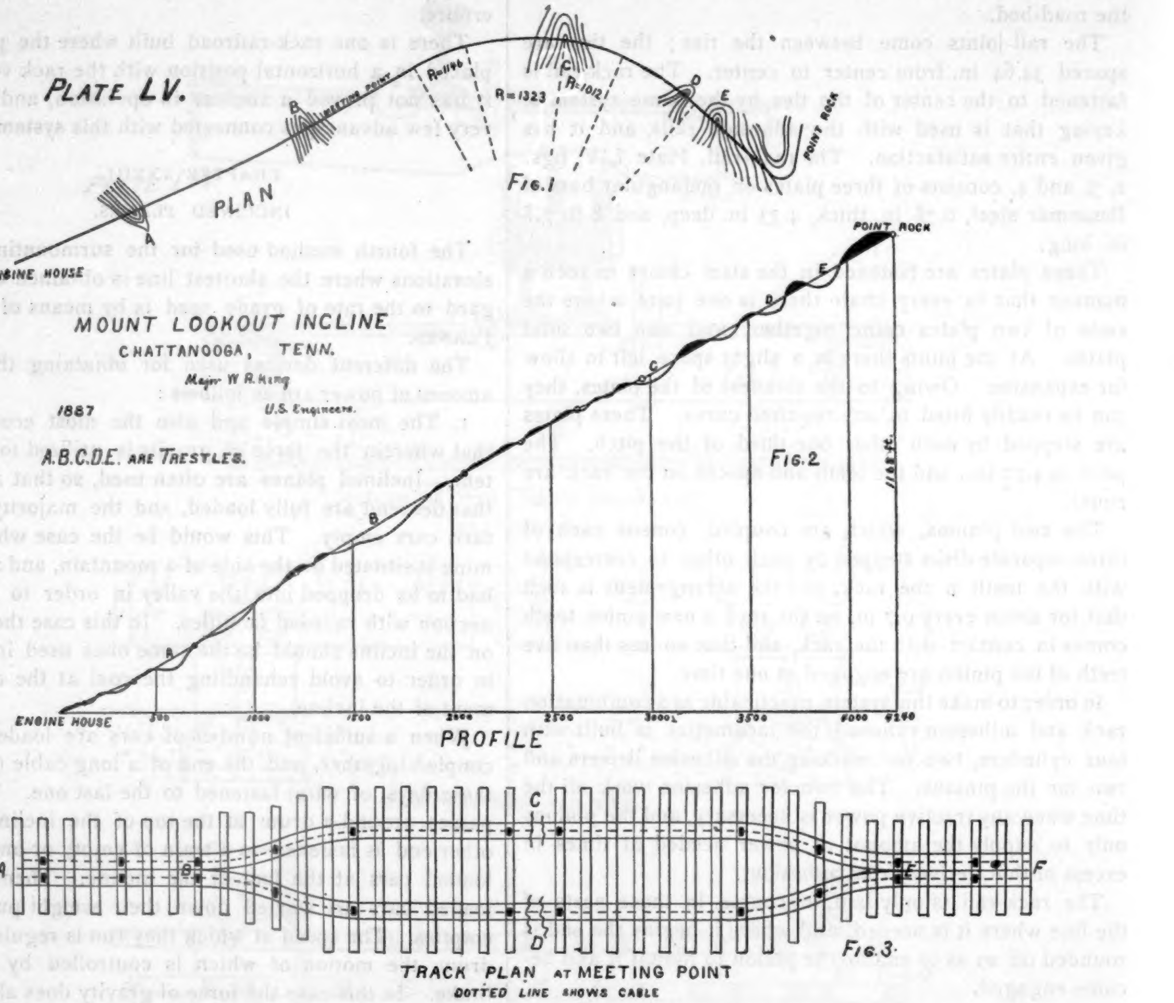
2. In order, however, to guard against any delays which might occur when it is desired to pull a train up the incline without a sufficient counterweight going down, the drum is connected with a stationary engine, so that power can be taken from that, and a rotary motion given to the drum, thus winding up the cable. In this method, which is the second, the steam-engine simply acts in connection with and as an aid to the force of gravity, which still does the greater part of the work.

In both these cases it is necessary that the incline should be straight and of as uniform a grade as possible. Even when this is the case the great friction of the cable uses up much of the power. Only one train each way can be run at the same time. Only one line of track is needed,

* The Author takes pleasure in acknowledging his indebtedness for some of the data on rack-railroads to Mr. E. E. Russell Tratman.

except in the middle, where the trains pass, and the switches should be perfectly automatic—that is, all trains running in the same direction must without fail keep to the same side at the passing point. In Plate LV, fig 3, let *A F* be the inclined plane. The dotted line represents the cable ; *C* and *D* represent the double track for the passing of the trains, and the switches, *B* and *E*, must be so constructed that by no possible chance can two trains moving in opposite directions get onto the same track at the passing point.

3. The third method is by use of the stationary engine and cable, without taking into account the force of gravity



as giving a possible increase to the power used. In this case the cable is usually of the endless type—that is, the two ends are fastened together. The cable runs around a drum or horizontal wheel at each end of the incline. One of these drums is connected with a stationary engine, and the cable has a sufficient number of turns around it to obviate all chance of slipping. A rotary motion is imparted to the drum, and this gives motion to the cable.

The cars are not attached permanently or to any particular part of the cable, but have a mechanical device called a clutch, by means of which they can take hold or let go of it at any time or place required, and thus stop and start as is necessary.

Provided there is motive power sufficient and sufficient strength in the cable, the only limit to the number of cars that can be run at the same time is the length of the cable.

In order to operate one of the inclines or roads to its full power, there should be a double track, so that trains should all run in the same direction on the same track.

In the first two methods mentioned of operating inclined planes, the inclines must be nearly straight and of practically uniform grade ; for this reason, the possibility of using them is very limited, and this requires special topographical features or great expense. In the cable system, however, this necessity of straightness and uniformity is done away with, and as many curves may be introduced as the nature of the case demands.

The best examples we have of roads (not properly inclined planes) run by continuous cable are the street railroads of San Francisco and Chicago. In the cable road the cable runs between the rails upon grooved wheels or rollers. In the case of the street railroads, it runs below the surface of the street in a deep groove that has only a narrow opening at the top, just wide enough to allow for the passage of the grip, and not wide enough to permit the entrance of a carriage wheel. The perfection to which each detail of this system of road has been brought makes their use possible and economical in many and varying cases. The latest example we have in this country of an inclined plane is that up Lookout Mountain, at Chattanooga, Tenn.

This incline was designed by and built under the personal supervision of Major W. R. King, U. S. Engineers. Plate LV, figs. 1 and 2, show the plan and profile of the

line. The total length is 4,360 ft., and the elevation attained 1,170 ft., giving a grade of 1 to 3¾.

The system employed is a combination of the balance and hoist principle, one train descending while the other ascends, both fastened to the ends of the same cable, which passes around a grooved pulley or drum at the top of the incline, and the endless cable system.

There are two cables used. The main cable, that runs on top and to which the cars are attached, runs around a pulley at the top, and is the length of the incline, 4,360 ft.

In the ordinary incline, worked upon the balance hoist principle, the stationary engine is at the top of the incline, but in this case this was impossible. The power, from necessity, was at the foot. This led to the use of the secondary cable, which runs under the main cable. This secondary cable is made fast to the ends of the main cable, and passes over a system of sheaves and pulleys at the foot of the incline, which are connected with and driven by a stationary engine.

This makes practically an endless cable, and in the operation the difference between it and the ordinary cable road is that while in the cable road the cable runs always in the same direction, in this the cable runs in one direction for a distance equal to the length of the incline, and then reverses and runs the same distance in an opposite direction.

The cable runs in the center of the track upon grooved pulleys. The track is as shown in Plate LV, fig. 3. There are three rails the entire distance, with the exception of the center point, where the outside rails diverge and the center one splits in two, as shown in the drawing, and thus makes a meeting-point for the trains where they can pass each other.

Three rails were used, in order to do away with all movable parts on the track at the meeting-point, and also from the fact that the greater width gave much more steadiness and solidity to track and road-bed.

Steel rails weighing 25 lbs. per yard were used, with cedar ties 9 ft. long. The rails are fastened down by means of 5-in. lag-screws, having 2 × 3 in. washers, which grip the rail base.

The main cable is 1¼ in. in diameter, composed of six strands of 19 wires each. The secondary cable is 1 in. in diameter, and composed of the same number of wires.

There is a factor of safety of 10 in the main cable, the maximum strain being 5 tons and the breaking strain 50 tons. The cars are built as low as possible, in order to secure greater steadiness. There are a number of novel and ingenious features in order to secure the most perfect safety. Among the most important is that of brakes.

In the first place, they are operated by a spring and by a chain and hand-wheel the same as the old-fashioned car brake, but with this difference, that in order to keep the brakes from working, or to hold the brake-shoe away from the wheel, the hand-wheel must be kept turned up all the time.

During the entire trip the brakeman is obliged to retain his hold on the wheel and keep it twisted. The minute he lets it loose the springs force the brake-shoe against the wheel and the train is stopped.

It is also so arranged that if the cable breaks the brakes are put on whether the brakeman lets go of the wheel or not. Another novel feature is the brake-shoes and their mode of operation. When the brakes are set they are forced under the wheels on the down-grade side, so that the minute the car begins to descend the wheels mount the shoes and are lifted from the track, the whole car resting on the shoes. The part of the shoes that comes against the rail being covered with fine steel points that bite the rail and prevent any slipping.

In order that the conductor may communicate with the engine-house from any part of the line, there is an insulated wire run along near the main cable.

This, with the cable, are connected with the two poles of a battery situated in the engine-house, and by bringing the two in contact a signal is rung in the engine-house. This connection can be made at any time or place from the car by pressing a small knob.

It is so arranged also that if the cable or anything else gives way the alarm is sounded. When the cable is in motion any signal, no matter what, means stop, while it requires a particular and rather elaborate signal to start the engine again.

From the tower of the engine-house, where the engineer has direct and absolute control over the engine, he also has unobstructed view of nearly the whole line. There are only two cars run, one each way, and the road is purely for pleasure travel. The engines used have two 12 × 18 in. cylinders, carry 75 lbs. steam working pressure, and consume about 90 lbs. of bituminous coal per round trip. The time of ascent is 6 minutes, or 8.26 miles per hour.*

(TO BE CONTINUED.)

SECONDARY STRESSES IN FRAMED STRUCTURES.

By I. Hiroi.

By the term *secondary stress* is to be understood that stress in a structure arising from more or less imperfect fulfillment of conditions upon which the first determination of stress (which we will call *primary stress* in contradistinction to the former) was based, as, for instance, the perfect flexibility of joints in framed structures, entire absence of eccentricity at connections, perfect workmanship, etc. That these conditions are not fulfilled in structures as usually built is evident to any one. There is no flexibility of joints in riveted bridges such as are most common in Europe, while in pin-connected ones, as constructed in America, friction between pin and eye is often great enough to produce considerable secondary stress.

Eccentricity at joint exists in most American bridges in lateral connections and in riveted bridges, quite often even in those of main truss members. Secondary stresses, arising from eccentricities at joints, can easily be calculated, and necessary additional section provided in every case for its own if required, and consequently in what follows we shall confine ourselves to the secondary stress arising from stiffness of joints.

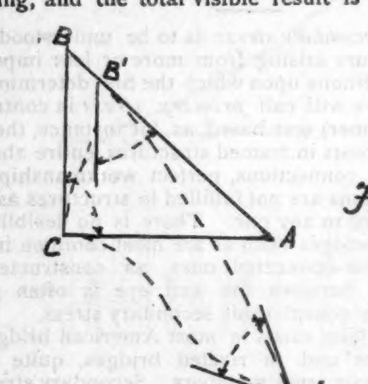
American engineers are so well satisfied with their pin-connected bridges that the question of secondary stress has been thus far a subject of very little interest, or rather but little known among many, although the writer remembers having seen some years ago in an engineering journal an article on the subject by a well-known bridge engineer, Mr. Charles Bender.

Evident as it is that the stress calculated under the supposition that every joint is flexible, so that each member without any resistance takes its new position in the strained truss, cannot be the same when there is any cause for such resistance, the secondary stress arising from stiffness of joints has long been more or less in the mind of every engineer; but the first mathematical investigation

* The description of this road is taken from a paper by W. H. Adams, M.E., New York, before the American Institute of Mining Engineers.

of the subject was made by a German engineer, H. Manderla, and made public in the *Allgemeine Bauzeitung* of June, 1880. But his formulæ are rather too complicated for the use of practical engineers. In what follows simpler formulæ of somewhat approximate character will be deduced, and an example worked out to indicate the method of procedure, which gives results accurate enough for all practical purposes when such calculation may be desirable, as in case of rather important structures.

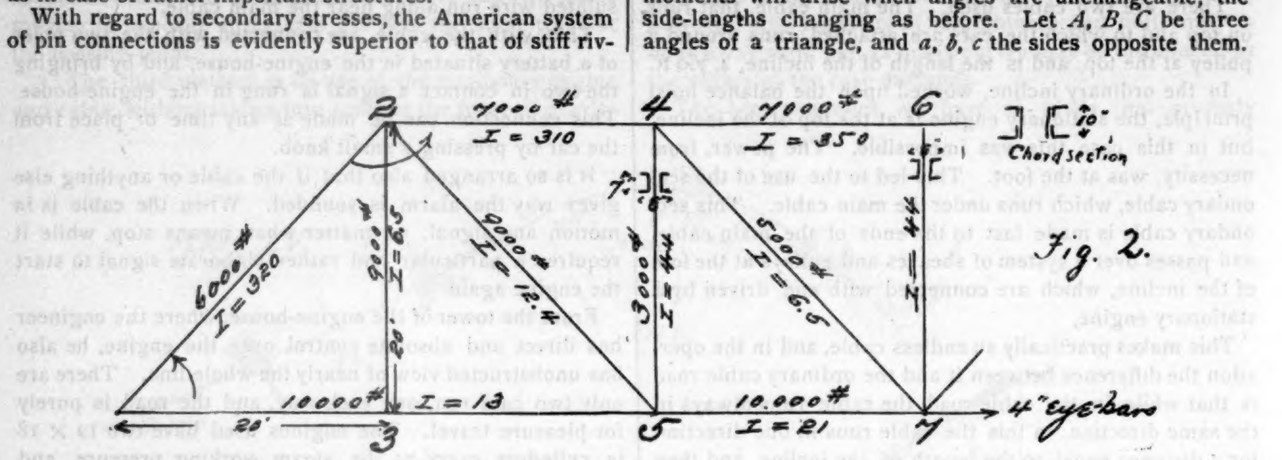
With regard to secondary stresses, the American system of pin connections is evidently superior to that of stiff riveting of most European bridges, but it is true only so long as the secondary moment is greater than the moment of pin friction against rotation. If the latter is greater than the former, then the case is simply that of a stiff riveted bridge. To look more closely into the first step of the discussion, suppose a straight truss be loaded with weights hung at panel points; then every member will be shortened or lengthened according as the stress is compression or tension, and as a consequence the triangles of which the truss consists become deformed, their angles more or less changing, and the total visible result is the deflection of



the truss from its original straight line. But now if the joint be made stiff, either by being riveted or held by friction of the pin, angles cannot change, and as a consequence each member has to deform itself to occupy its new position as shown dotted in the adjoining figure, in which the undeformed triangle $A\ B\ C$ is brought together at C with itself in its deformed state. $B\ C$ has shortened, $B\ A$ and $A\ C$ elongated, and since the angles cannot change, sides become curved, preserving at their ends the included angle equal to the original, or, in other words, the tangents to the elastic line at points C, B', A' form angles exactly equal to angles at C, B, A.

Thus it is evident that under such circumstances bending moments exist in every member. These moments give additional fiber stress which we call the secondary stress due to the stiffness of joints. It is true that when secondary stresses exist, the normal stresses which worked those changes of lengths of members are somewhat less than when none exists, since a part of it is taken up in producing the secondary stress, and as a consequence the position of every panel point in the deformed truss is not exactly the same under both circumstances; but the difference is so small that we can assume without any appreciable error that they are alike, and also that the normal stresses themselves remain unchanged.

The first step in the calculation of the secondary stress is to calculate the changes of angles of every triangle, due to the changes of side-lengths, under the supposition that every joint is perfectly flexible, and then to find out what moments will arise when angles are unchangeable, the side-lengths changing as before. Let A, B, C be three angles of a triangle, and a, b, c the sides opposite them.



We will denote with prefix Δ the amount of deformation of sides and angles. Suppose now the sides a, b, c change by Δa, Δb, Δc, then the simple trigonometrical relations give at once:

$$(b + \Delta b) \sin (A + \Delta A) = (a + \Delta a) \sin (B + \Delta B).$$

Neglecting very small quantities, and transforming we obtain:

$$\Delta A = \left(\frac{\Delta a}{a} - \frac{\Delta b}{b}\right).\ \tan A + \Delta B.\ \frac{\tan C}{\tan B}$$

Similarly: $\Delta C = \left(\frac{\Delta c}{c} - \frac{\Delta b}{b}\right).\ \tan C + \Delta B.\ \frac{\tan C}{\tan B}$

But $\Delta A + \Delta C + \Delta B = 0$.

Consequently:

$$\Delta B = \frac{\Delta b}{b} (\cot A + \cot C) - \frac{\Delta a}{a} \cot C - \frac{\Delta c}{c} \cot A \quad (1)$$

Symmetry gives:

$$\Delta C = \frac{\Delta c}{c} (\cot A + \cot B) - \frac{\Delta a}{a} \cot B - \frac{\Delta b}{b} \cot A \quad (2)$$

$$\Delta A = \frac{\Delta a}{a} (\cot B + \cot C) - \frac{\Delta b}{b} \cot C - \frac{\Delta c}{c} \cot B \quad (3)$$

With these three equations we can at once determine changes of angles due to changes of sides.

Let us take, for example, a railroad bridge 120 ft. long, consisting of six panels, and 20 ft. deep. Proportioning the bridge for a uniform rolling load of 3,000 lbs. per lineal foot, with the allowed stress of 10,000 lbs. per square inch for tension and 8,000 lbs. for compression, the latter further reduced according to Gordon's formula, we find that under *full* loading (for which case the secondary stress will be calculated) the truss will be subjected to stresses as given in the figure along each member for 1 square in. I is the moment of inertia of the section and given in inches.

All ties are 4-in. eye-bars, and vertical posts 7-in. channels.

Assuming the modulus of elasticity of iron to be 29,000,000 lbs. per square inch throughout, we obtain the following changes of lengths:

$$\Delta\,13 = \Delta\,35 = \Delta\,57 = \frac{10000}{29000000} \times 20 = .000345 \times 20'$$

$\Delta\,12 = -\ .000207 \times \sqrt{800'}$ $\quad \Delta\,24 = \Delta\,46 = .000241 \times 20'$

$\Delta\,23 = \ .00031 \times 20'$ $\quad \Delta\,25 = \ .000310 \times \sqrt{800'}$

$\Delta\,47 = \ .000172 \times \sqrt{800'}$ $\quad \Delta\,45 = -\ .000103 \times 20'$

$\Delta\,67 = 0$

For right-angled isosceles triangles, equations (1), (2) and (3) become

$$\Delta B = \frac{\Delta b}{b} - \frac{\Delta a}{a} \tag{4}$$

$$\Delta C = \frac{\Delta c}{c} - \frac{\Delta a}{a} \tag{5}$$

$$\Delta A = \frac{2.\Delta c}{a} - \frac{\Delta b}{b} - \frac{\Delta c}{c} \tag{6}$$

Applying these equations to every triangle of the truss, and substituting the respective side-deformations, we obtain the changes of angles expressed in length of arc:

$\Delta 213 =$ .000310 + .000207 = .000517

$\Delta 123 =$ .000552 $\quad \Delta 132 = -$ .001069

$\Delta 325 =$ .000035 $\quad \Delta 253 =$ 0

$\Delta 235 = -$ .000035 $\quad \Delta 425 = -$ .000413

$\Delta 254 = -$ .000551 $\quad \Delta 245 =$ .000964

etc., etc.

We will now proceed to examine the condition of affairs in a single member, when the joints do not allow such changes in angles. Let $A\,B$ be any member, say, a strut. Here it may be remarked that struts are the only members that are influenced by secondary stresses to any extent, as will be seen further on.

Further, let N, N' be normal stresses, which, as already said, may be assumed to be equal to the primary stress of

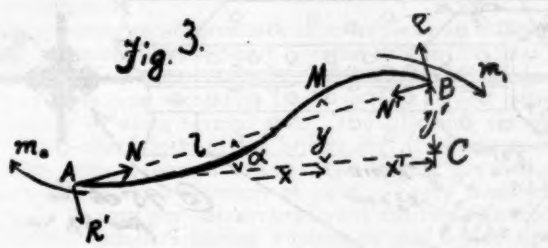


Fig. 3.

the member. $A\,C$ is the original direction of the strut and tangent to the curve at A; α, the angle included between two positions of the strut. m_0 and m_1 are the moments acting at and away from A and B; R and R' the tangential stresses. If the primary stress does not pass through the axis of the member, it may be decomposed at both ends into normal and tangential stresses, N, R; and the moments changed by the amount of eccentricity multiplied by the force itself. A moment will be called positive when it turns in the same direction as the hand of a watch, and negative when contrary, around any point.

Since stresses in the member are in equilibrium, and as no external force is supposed to be acting on it, it follows from the general equations of equilibrium Σ vertical forces = 0, Σ horizontal forces = 0, Σ moments = 0, that

$$R - R' = 0$$

$$N - N' = 0$$

at B, $$m_0 - R\,l + m_1 = 0$$

or $$R = \frac{m_0 + m_1}{l}$$

Let M be the resultant at any point $x\,y$ of moments acting on the left of the point, the co-ordinate axis being taken on $A\,C$, with origin at A; then

$$m_0 - R\,x - M = 0$$

In this equation the influence of N is omitted, because its effect in producing moment is quite small compared with others, as the bending of a member is under all circumstances entirely inconsiderable.

Substituting the value of R and setting the value of M in the general equation of elastic line, we obtain:

$$m_0 - \frac{m_0 + m_1}{l}\,x = M = E\,I\,\frac{d^2 y}{d\,x^2}$$

in which E is the modulus of elasticity and I the moment of inertia, both of which we will assume to be uniform throughout the member.

Integrating the equation twice, we get:

$$\frac{dy}{dx} = \frac{1}{E\,I}\left(m_0\,x - \frac{m + m_1}{2\,l}\,x^2\right)$$

$$y = \frac{1}{2\,E\,I}\left(m_0\,x^2 - \frac{m_0 + m_1}{3\,l}\,x^3\right) \tag{7}$$

Since α is in any case a very small angle, we can put

$$l = x^1 \text{ and } \alpha = \frac{y^1}{l}$$

In equation (7) putting $x = l, y = y^1$, we obtain:

$$y^1 = \frac{l^2}{6\,E\,I}\left(2\,m_0 - m_1\right)$$

$$\alpha = \frac{y^1}{l} = \frac{l}{6\,E\,I}\left(2\,m_0 - m_1\right) \tag{8}$$

Calling α positive when deflecting to the right and negative when to the left, and designating with subscript

Fig. 4.

the member to which it belongs, we have for any angle 213 the value of its deformation:

$$\Delta 213 = \alpha_{13} - \alpha_{12}$$

Substituting the value of α in equation (8), with proper subscripts we obtain:

$$6\,E.\,\Delta 213 = \frac{l_{13}}{I_{13}}\left(2\,m_{13} - m_{31}\right) - \frac{l_{12}}{I_{12}}\left(2\,m_{12} - m_{21}\right) \tag{9}$$

This entirely general equation furnishes as many equations as there are angles. But there are two unknown quantities in each member. The remaining necessary equations come from the condition that for equilibrium the algebraic sum of all the moments must be = 0 at every joint, or $\Sigma\,m = 0$. And in the figure

$$m_{12} + m_{13} = 0 \tag{10}$$

Returning now to our truss, we apply these two equations at every joint and obtain following equations:

At (1)

$$6\,E.\,\Delta 213 = .000517 \times 6\,E = 87958$$

$$87958 = \frac{240}{13}\left(2\,m_{13} - m_{31}\right) - \frac{340}{320}\left(2\,m_{12} - m_{21}\right)$$

$$m_{12} + m_{13} = 0$$

at (2)

$$-\,71.862 = \frac{340}{12.4}\left(2\,m_{25} - m_{52}\right) - \frac{240}{310}\left(2\,m_{24} - m_{42}\right)$$

$$6090 = \frac{240}{6.5}\left(2\,m_{23} - m_{32}\right) - \frac{340}{12.4}\left(2\,m_{25} - m_{52}\right)$$

$$96048 = \frac{340}{320}\left(2\,m_{21} - m_{12}\right) - \frac{240}{6.5}\left(2\,m_{23} - m_{32}\right)$$

$$m_{24} + m_{25} + m_{23} + m_{21} = 0$$

at (3)

$$-\,186006 = \frac{240}{6.5}\left(2\,m_{32} - m_{23}\right) - \frac{240}{13}\left(2\,m_{31} - m_{13}\right)$$

$$6090 = \frac{240}{13}\left(2\,m_{35} - m_{53}\right) - \frac{240}{6.5}\left(2\,m_{32} - m_{23}\right)$$

$$m_{31} + m_{32} + m_{35} = 0$$

etc., etc., etc.

The direction in which we have taken α as positive and negative should be remembered, and so applied at every angle. Since the loading is symmetrical, it is evident that there exists no secondary stress in member 47, what comes from one side being neutralized by equal moment from the other.

Solving the above equations, we obtain values of several m's in inch-pounds :

$m_{12} = -\ 4400 \quad m_{13} = +\ 4400$
$m_{24} = +\ 8000 \quad m_{26} = -\ 1500 \quad m_{23} = -\ 2500$
$m_{35} = -\ 2100 \quad m_{32} = -\ 2500 \quad m_{31} = 4600$
$m_{42} = +\ 49000 \quad m_{46} = -\ 10000 \quad m_{47} = -\ 1000$
$m_{45} = 40000$

etc., etc.

The deformations when exaggerated give a form to the truss, as in the figure :

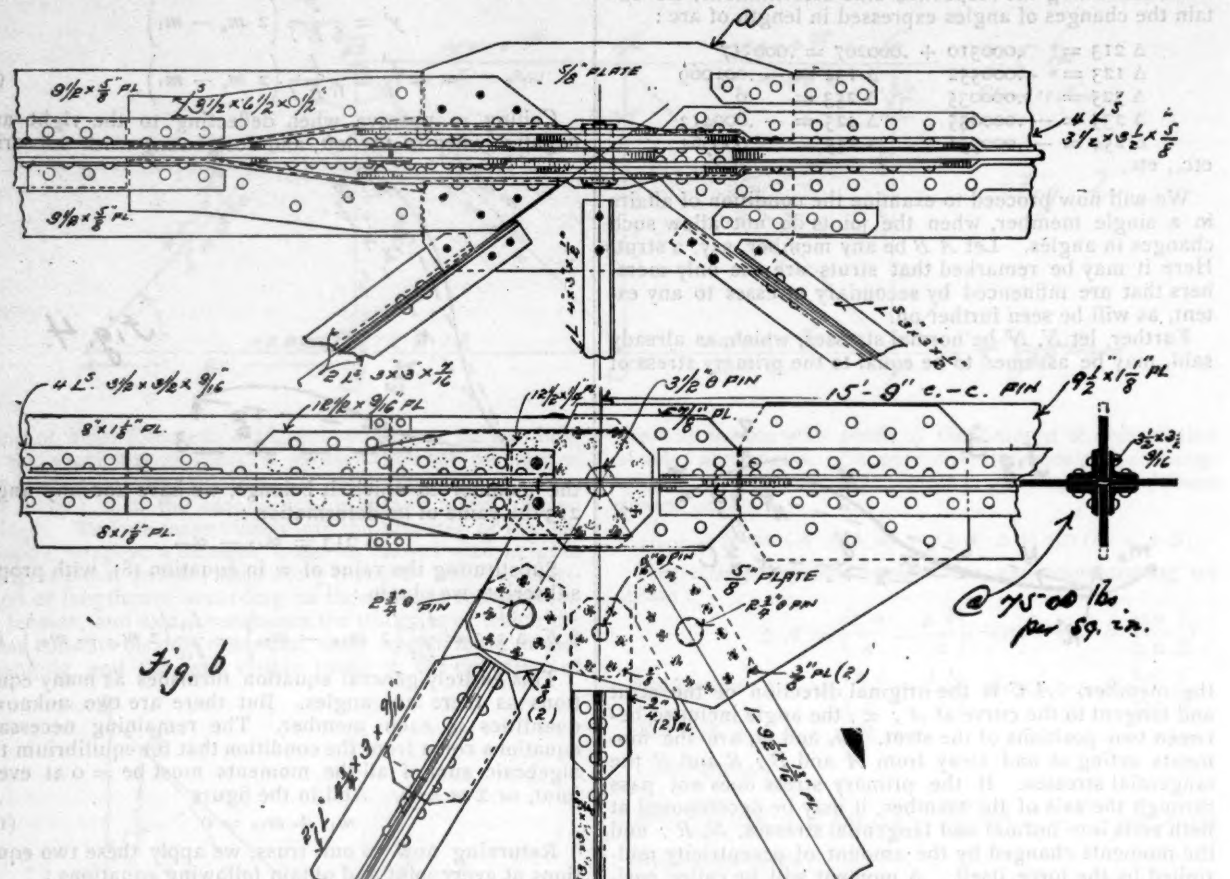
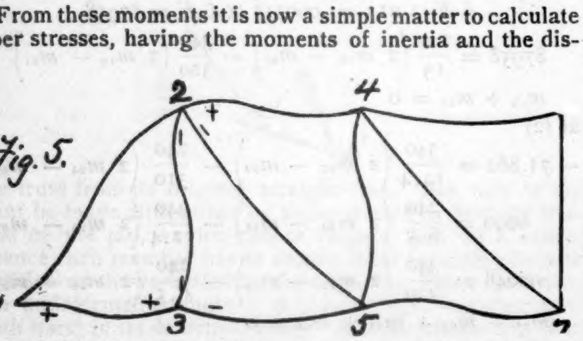


Fig. 6

From these moments it is now a simple matter to calculate fiber stresses, having the moments of inertia and the distances of furthest fibers of every member.

Fig. 5.



Thus we have :

in 24 near 4 $\frac{49000}{310} \times 5 = 800 \pm$ per sq. in. $= 11\frac{1}{3}\%$ primary stress

" 46 " 6 $\frac{40000}{350} \times 5 = 580$ " $= 8\ \%$ " "

" 45 " 4 $\frac{10000}{44} \times 4 = 910$ " $= 15\ \%$ " "

etc. etc.

The secondary stresses in tension members are quite small, except once in the hanger near (3), where it amounts to 8 per cent. Eye-bars possess, however, near their ends much greater moment of inertia than in the body, consequently the effect of the secondary moment is very small. It is the compression members that are greatly influenced by the secondary moment. The normal stress, N, which we have omitted in the equation of the moment, while it tends to counteract in case of tension members any end moments, in compression ones helps to bend more and more. It must be remembered that the truss we have taken as an example is a kind comparatively free from secondary stress. In Warren girders it is not unusual that a stress of more than 100 per cent. of primary stress is found in some of its parts.

Returning once more to our fundamental equation (8), we see that the greater the moment m_0 the greater will be the departure $\propto$; consequently, the worst case arises where two compression members are closed by a tension member, as the specific change of length in the latter is always greater than in the former. This fact is to be observed in moments m_{34} and m_{62}. Tensile members, when they possess but small amounts of moment of inertia, by which great bending moment cannot exist without bending the bar to a considerable extent which, in turn, is not possible on account of the great normal stress, are favorable to stiff compression members with which they meet, as at every point the algebraic sum of moments must be $= 0$. Too wide eye-bars should not be used, not only because they are stiff, but also because they necessitate the use of pins of proportionally great diameter, which becomes the cause of great frictional resistance.

Further, in that equation we find that for the given value of y, the greater l is, the smaller will be the value of $\propto$; hence long panels and deep truss will tend to reduce the secondary stress.

At the moment the scaffolding is removed from under the structure, it may be supposed that every member has taken its proper position in the strained truss, so that there exists no secondary stress. Under such circumstances it is evident that the secondary stress is to be expected only from the *moving load.*

Now, coming to pin connections, it is merely necessary to find out the amount of frictional resistance, and com-

pare it with the secondary moment at that place. Since we are not certain as to the coefficient of friction, especially under such high pressures, it is hardly of use to enter into the elaborate calculation. Take, for example, joint 2. Allowing 15,000 lbs. per square inch for fiber stress on the pin, and taking everything into consideration, a 4-in. diameter-pin will not be found to be too large. If we assume the coefficient of friction to be 0.3, we find the frictional resistance of the pin against the motion of chord 24 to be about

$$160000 \times .3 \times 2 \text{ in.} = 96000 \text{ inch-pounds,}$$

which is more than 10 times the secondary moment. It may be well to rivet up such joint to protect the pin, at least, from torsional stress, as it is a stiff joint after all. As to the rest of the chord-joints, they are all stiff joints, as in all American bridges they are spliced to the extent of from 25 to 100 per cent. of chord sections, according to specifications. The only movable members are webs. At joint 4 the diameter of pin will be, with the allowed pressure of 12,000 lbs., equal to $\frac{40000}{12000} = 3\frac{3}{8}$ in. This offers to the post the resistance of

$$20,000 \times .3 \times \frac{27}{16} = 10,100 \text{ inch-pounds,}$$

which is little more than the secondary moment at that place.

Comparing in this way, it will be found that in most American bridges the friction of pins is much greater than the secondary stress, so that they assume the character of riveted bridges.

It is interesting to observe how in some German bridges (namely, those built by the South German Bridge Company, according to the patent system of Gerber) joints are so designed as to reduce secondary stress to the smallest possible amount by using several pins. The adjoining sketch shows a top-chord joint of the bridge over the Main near Wertheim, with a span of 220 ft. The largest pin in the whole structure has a diameter of $3\frac{1}{2}$ in. Every member turns upon its *own* pin—an arrangement entirely different from several members having a common pin, whose size naturally depends upon the resultant action of all the stresses. Thus the vertical has a pin $1\frac{1}{16}$ in. in diameter, having but about $\frac{7}{8}$ in. leverage for frictional moment. A somewhat large amount of secondary stress in top-chord is still unavoidable, but by such arrangement it is kept down to a very small percentage of the primary stress. Plates *a*, which easily bend in vertical plane, give all the lateral stiffness that is desired, while helping to transmit a part of the stress from one section to another. There is no eccentricity in connections of either main or lateral connections, and the whole skeleton allows a very exact calculation of stresses in members.

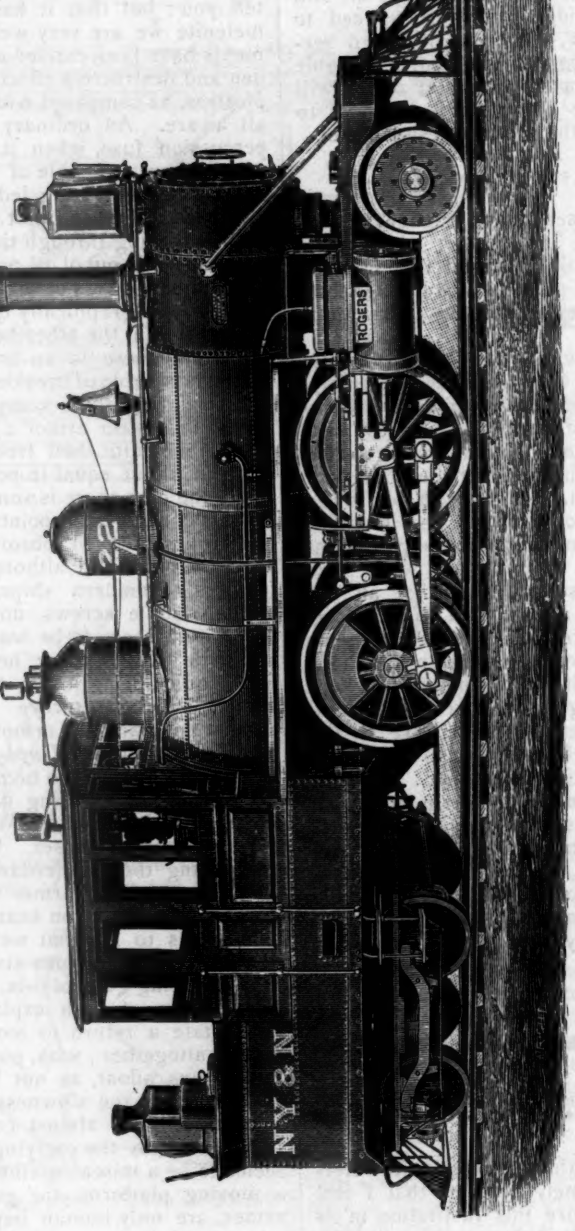
Such a construction, however, merely shows how secondary stresses can be reduced, and is hardly practicable in the competitive works of American bridge-building, which require greater simplicity and more economical sections.

Effect of High Explosives on the Design of Warships.

(Abstract of paper read before the Institution of Naval Architects at Glasgow, Scotland, by Captain Fitz Gerald.)

THE data which I have been able to collect with reference to my subject is so extremely meager, that I feel almost ashamed to bring it before this Institution in its present stage; and my only excuse for doing so is the great interest and importance which attaches to it, and the urgency, if I may so express it, of the subject of high explosives used in shell fired from regular powder guns, not pneumatic tubes. I am also in hopes that some of our naval architects may have been prying into the future by watching experiments and collecting information, and that they, perhaps, may be able to throw more light on the subject than I can do, and that the discussion which I hope will take place, will, at any rate, cause us to realize that we are face to face with a new method of attack, which may very possibly call for some modifications in ship designs for war purposes. In spite of the cloud of secrecy which our neighbors have endeavored to cast about the subject, we have been aware for some time back that they have been making experiments with a high explosive called melenite, a species of blasting gelatine, which, I am informed, is poured liquid into the shell, and then allowed to solidify. The explosive force of melenite is about equal to gun-cotton, weight for weight, but volume for volume it is much greater; that is to say, melenite is heavier, so that in a given space, say the interior of a shell, you can put half as much again of melenite as gun-cotton. The difficulty of using high explosives in shell has hitherto been the liability of the concussion of the gun causing the shell to burst in the bore, and thus to destroy the gun. How this difficulty has been overcome, I am not in a position to tell you; but that it has been overcome in the case of melenite we are very well assured, as numerous experiments have been carried out with it. As to the more sudden and destructive effect of what are called the high explosives, as compared with gunpowder, you are, no doubt, all aware. An ordinary gunpowder shell fitted with a percussion fuse, when it struck the thin side of a ship which it was capable of penetrating, passed several feet onward before it exploded; but shells fitted with high explosives are said to burst actually on contact, or when the shell is passing through the thin side, so that the destruction caused is out of all proportion to the gunpowder shell, many square yards of the side being actually blown away, or, as it was graphically described to me, nothing left but daylight. On the other hand, it is somewhat cheering to hear that there is an antidote, and that very moderate armor is capable of breaking up these high explosive shells, and rendering them comparatively harmless. Thus it is stated that steel armor 4 in. thick is capable of breaking up the melenite shell from the French 16 centimeter gun —a gun about equal in power to our 6-in. gun. If this is really the case there is something hopeful in the prospect for this country, as it points to an important future for our numerous so-called obsolete thin-armored ships. They are iron built, and although they lack many of the best features of modern ships, such as numerous compartments, double screws, under-water steering gear, etc., they would seem to be worth re-engining and re-arming, not with two or three heavy guns, but with numerous light, quick-firing ones, firing high explosives. They would, I believe, prove formidable fighting machines against any partially armored ships. It is stated that the new French cruiser, *Dupuy-de-Lome*, of 4,000 tons, and a speed of 19 knots, is to be plated with 4-in. steel armor, for the purpose of breaking up high explosive shell, though she appears in Lloyd's "Warships of the World" as only a deck-protected cruiser. It is also stated that the French are plating their cofferdams with a similar object. This would be internal armor with a vengeance. But I only give you the report on hearsay evidence.

It seems to me that we are working round in a circle in this question of guns and armor; and the introduction of quick-firing guns of 6-in. caliber, and the very probable introduction of high explosives in shell, will, I think, necessitate a return to moderate armor and lighter armaments altogether; with, possibly, the abandonment of very heavy guns afloat, as not being worth their weight and trouble, when the slowness of their fire is taken into consideration. The almost complete sacrifice of a ship of 10,000 tons to the carrying of two or three heavy guns seems to be a miscalculation of the chances of hitting from a moving platform—for gunners, after all, even behind armor, are only human beings, and liable to make mistakes; and it seems likely that the introduction of high explosives in shell of moderate caliber will help to bring us back again to some modification of the type of our earlier ironclads, so as to insure us against the greater number of chances; for we must ever bear in mind that it is simply a question of chances. There is no absolute safety, nor anything approaching to it, in any design of warship; and the recent practice of reducing greatly the extent of armor, for the purpose of thickening it in places, has exposed large areas as happy hunting-grounds for high explosive shell of small caliber. Almost all modern ships have many such places which they cannot afford to



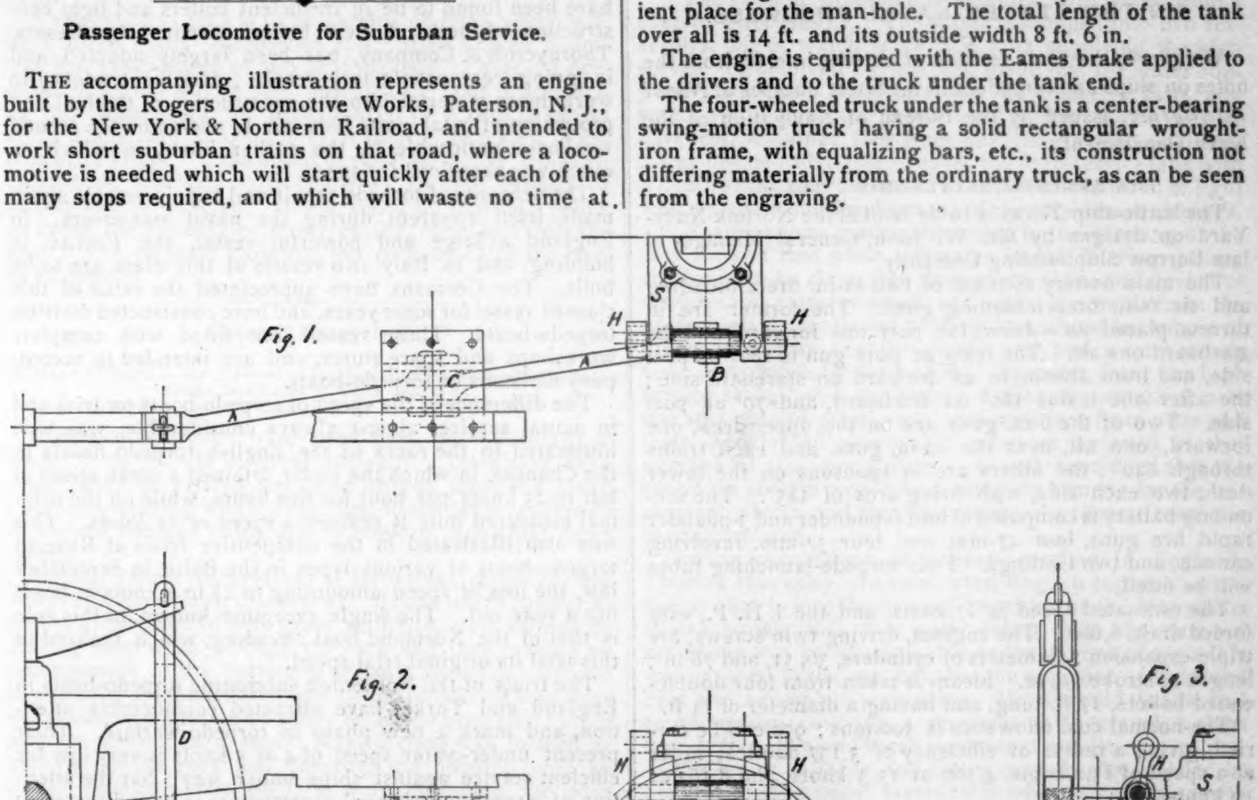
LOCOMOTIVE FOR SUBURBAN PASSENGER SERVICE.

BUILT BY THE ROGERS LOCOMOTIVE AND MACHINE WORKS, PATERSON, N. J.

see destroyed with impunity. I should like to know, for instance, how these huge Italian ships, with hardly any armor—ships which some of our naval architects so greatly admire—will get on when their sides in the region of their water-lines are attacked with explosive shell, and large areas of them blown away. I should imagine that they would get a heavy list, if, indeed, the righting-lever does not disappear altogether, and I cannot see that the weight of armor expended in their submerged decks will be of much value to them. It will be seen that my remarks are merely intended to be suggestive. I have made no attempt to dogmatize on the subject of high explosives. The question is in an untried and speculative stage, and my only object is to draw attention to it, and to urge our naval architects to watch closely the experiments which are about to take place with the *Resistance* in this connection; and I sincerely hope that there will be no hollow pretense at secrecy about these experiments, for the only result of such tactics will be to hide useful information for a certain time from our own naval architects, while foreigners will certainly obtain all they require.

Passenger Locomotive for Suburban Service.

THE accompanying illustration represents an engine built by the Rogers Locomotive Works, Paterson, N. J., for the New York & Northern Railroad, and intended to work short suburban trains on that road, where a locomotive is needed which will start quickly after each of the many stops required, and which will waste no time at terminal stations. In some respects it differs considerably from other engines built for a similar purpose.



As shown by the engraving, which is made from a photograph of the engine, the tank is carried upon the frame. There are four drivers, with a four-wheeled truck under the tank end and a two-wheeled or pony truck forward of the cylinders.

The principal dimensions of these engines are as follows:

Gauge of road	4 ft. 8½ in.
Diameter of cylinders	14 in.
Stroke of cylinders	22 in.
Diameter of driving wheels	54 in.
Rigid wheel-base	6 ft. 3 in.
Total wheel-base	27 ft.
Diameter of boiler barrel at smoke-box end	52 in.
Length of flues	7 ft. 10¾ in.
Diameter of flues	1¾ in.
Length of fire-box	71½ in.
Width of fire-box	41 in.
Height of fire-box, front end	47 in.
Height of fire-box, back end	43 in.
Grate area	20 4 sq. ft.
Total weight of engine	98,500 lbs.
Weight on drivers	50,000 lbs.

These engines have a water-grate and burn anthracite coal. The capacity of the tank is 1,000 gallons of water, and three tons of coal can be carried. The legs of the tank extend forward on each side of the fire-box in front of the cab, and from the frame up the running-board; a pocket is formed in the side for a step, as shown in the illustration. The water-space is made higher at the back in order to give additional room and to provide a convenient place for the man-hole. The total length of the tank over all is 14 ft. and its outside width 8 ft. 6 in.

The engine is equipped with the Eames brake applied to the drivers and to the truck under the tank end.

The four-wheeled truck under the tank is a center-bearing swing-motion truck having a solid rectangular wrought-iron frame, with equalizing bars, etc., its construction not differing materially from the ordinary truck, as can be seen from the engraving.

A sketch of the two-wheeled truck is given herewith, fig. 1 being a half plan, fig. 2 an elevation, and fig. 3 a half cross-section. The drivers have an equalizing lever between them as usual, but the forward hanger of the forward driving springs extends down on each side below the frame and carries the end of an equalizing bar *A*, the other end of which extends to the swing-hanger of the truck, forming a lever, the fulcrum of which is a pin carried by the frame underneath the cylinder saddle at *C*. The forward end of this lever is connected with the truck by stirrups *B B*, which are carried on the hanger-pins of the truck between the arms of the spring bolster or cradle; as this cradle has no lateral motion, the stirrups *B B* have

also no lateral motion, and the equalizing levers *A A* retain the same position in relation to the main frame of the engine as to lateral movement. The arrangement will be readily seen from the drawings. The pin at the center of the equalizing lever of the truck could as well be made at right angles with the center line of the bar, but in this engine it was made at right angles to the frame simply to avoid the necessity of making right and left-hand patterns for the casting which holds it, the equalizing bars being forged in the proper shape to suit it. This arrangement of truck and equalizer has proved in practice strong and durable; it also makes a very neat job, and is apparently preferable to the somewhat unsightly arrangement of levers over the frame and back of the smoke-box, which is often used in similar cases.

The general design of the engine, especially that of the truck and equalizers, is due to Mr. Reuben Wells, Superintendent of the Rogers Works.

These are certainly very neat, compact, and serviceable-looking engines, and have so far given satisfaction in a very trying service.

UNITED STATES NAVAL PROGRESS.

WE give below some extracts of current interest from the notes on ships and torpedoes in the latest number of *Naval Intelligence*, issued by the Bureau of Navigation of the Navy Department.

THE ARMORED BATTLE-SHIP "TEXAS."

The battle-ship *Texas* is to be built at the Norfolk Navy-Yard on designs by Mr. W. John, General Manager of late Barrow Shipbuilding Company.

The main battery consists of two 12-in. breech-loading and six 6-in. breech-loading guns. The former are in turrets placed *en echelon*, the port one forward and the starboard one aft. The train of port gun is 180° on port side, and from abeam to 40° forward on starboard side; the after one trains 180° on starboard, and 70° on port side. Two of the 6-in. guns are on the upper deck, one forward, one aft, near the 12-in. guns, and each trains through 240°; the others are in sponsons on the lower deck, two each side, with firing arcs of 115°. The secondary battery is composed of four 6-pounder and 3-pounder rapid fire guns, four 47-mm. and four 37-mm. revolving cannon, and two Gatlings. Four torpedo-launching tubes will be fitted.

The estimated speed is 17 knots, and the I. H. P., with forced draft, 8,600. The engines, driving twin screws, are triple-expansion; diameters of cylinders, 36, 51, and 78 in.; length of stroke, 39 in. Steam is taken from four double-ended boilers, 17 ft. long, and having a diameter of 14 ft.

The normal coal allowance is 500 tons; 950 can be carried, giving a radius of efficiency of 3,137 nautical miles at a speed of 15.2 knots, 4,500 at 13.3 knots, and 8,592 at 10 knots.

For defense the vessel has a water-line belt of 12-in. steel armor in wake of magazines, engines, and boilers. The ends are connected by athwartship 6-in. steel bulkheads. An armored redoubt runs diagonally across on main deck, enclosing and protecting bases of turrets and their machinery; this as well as the turret armor is 12-in. steel. The conning-tower has the same protection. The ammunition tubes have 6-in., and tube from conning-tower down to protective-deck, 3-in. steel protection. The protective-deck, 3 in. thick, covers the armor belt and curves down forward and abaft it to stem and stern. Coal bunkers are outboard of, and above boiler and engine-rooms.

Between the starboard and port fire-rooms are magazines and shell-rooms, with a fore-and-aft passage above them communicating with additional ammunition spaces forward of fire-room and abaft engines.

The displacement, at normal draft of 22 ft. forward and 23 ft. aft, is 6,300 tons; with 950 tons of coal on board, it is 6,750 tons.

The length between perpendiculars is 290 ft., and extreme beam, 61 ft. 1 in.

The *Texas* is to be built of steel. She will have a double bottom and numerous water-tight compartments; there are to be two masts with military tops; electric search-lights are to be placed on hurricane deck and chart-house. The estimated cost, exclusive of armament, is $2,376,000.

TORPEDO-BOATS.

The naval maneuvers of 1887 abroad confirmed the opinion formed in 1886 that torpedo-boats of small tonnage are not adapted for service at sea, and that their field of operations is restricted to operations on or near the coast and in harbors. The tendency at present is to build boats exceeding 130 ft. in length, with displacements ranging above 90 tons, carrying machine and rapid-fire guns in addition to the torpedo armament.

European powers have begun but a comparatively small number of torpedo-boats during the present year, although a large number have been added to the strength of the fleets; but these have, in a majority of cases, been completed in fulfilment of old contracts.

In general, it may be fairly said that the smaller type of torpedo-boat, so highly thought of in 1885, has lost much of its prestige.

The principal sources of weakness in the smaller boats have been found to lie in inefficient boilers and light construction of hull. A new boiler, invented by Messrs. Thornycroft & Company, has been largely adopted, and is giving very satisfactory results; and the tendency to work more material into the construction of the hull and protection of vital parts bids fair to overcome the second weakness noticeable in the earlier boats, in which so much was sacrificed for speed.

The necessity of torpedo repair and supply vessels again made itself apparent during the naval maneuvers. In England a large and powerful vessel, the *Vulcan*, is building, and in Italy two vessels of this class are to be built. The Germans have appreciated the value of this class of vessel for some years, and have constructed division torpedo-boats. These vessels are fitted with complete workshops and spare stores, and are intended to accompany divisions of torpedo-boats.

The difference of the speed of torpedo-boats on trial and in actual service, almost always considerable, was well illustrated in the races of the English torpedo flotilla in the Channel, in which the victor attained a mean speed of but 16.25 knots per hour for five hours, while on the original measured mile it realized a speed of 21 knots. This was also illustrated in the competitive trials of Russian torpedo-boats of various types in the Baltic in September last, the loss of speed amounting to 2½ to 4 knots in boats but a year old. The single exception known to this rule is that of the Normand boat *Sveaborg*, which realized in this trial its original trial speed.

The trials of the Nordenfelt submarine torpedo-boats in England and Turkey have attracted considerable attention, and mark a new phase in torpedo warfare. Their present under-water speed of 4 or 5 knots is very low for efficient service against ships under way; but the attention of inventors and naval constructors is now directed to this type of boat, and doubtless it will be largely developed in the future. In a circular recently issued by the Navy Department calling for proposals for a submarine torpedo-boat an under-water speed of 8 knots is deemed requisite. This circular probably indicates the most advanced thought and opinion in regard to submarine boats.

The *Stiletto* had her final official trials in Narragansett Bay, on August 20, 1887. The trials consisted of a three hours' run over a measured distance. The weather was very favorable, sea smooth, and no wind. The total weight carried was 9 tons, 640 pounds, which included 4 tons, 540 pounds of coal. The displacement with this load was 31 tons. Draft of water before trial, forward, 2 ft. 9 in.; aft, 2 ft. 10 in. After the trial the draft forward was 2 ft. 7 in., and aft, 2 ft. 8 in. The mean speed for the three hours' run was 18.22 knots. The vibration at high speed was moderate. A navy compass was quite steady wherever placed. The mean I. H. P. developed by the engines was 359. The endurance with 5 tons of coal is computed at 507 miles at a speed of 11 knots.

The *Stiletto* was bought by the U. S. Government for $25,000, and turned over to the Torpedo Station, on May 28, 1888.

Messrs. Herreshoff, of Bristol, R. I., have signed a contract, March 1, 1888, to build for the U. S. Navy a deep-sea twin screw torpedo-boat, exclusive of torpedoes and their appendages, for $82,750, of the following dimensions: Length over all, 138 ft.; length on deck, 134 ft.; extreme breadth, 15 ft.; extreme depth, keel to crown of deck amidships, 10 ft. The keel will be rocker-shaped, the draft aft, 4 ft. 8 in. The displacement will be about 100 tons, and the H.P. is estimated at 1,600. The engines are to be five-cylinder quadruple expansion, driving twin screws. The two boilers are to be of Herreshoff's latest design, and placed in separate compartments forward and abaft the engine-room. Eight bilge-ejectors will give a total discharge of 280 tons per hour. A steam steering engine will be fitted to work a balance rudder of large area. The engines and boilers will be protected by coal. The interior will be divided into 11 water-tight compartments and lighted by electricity. There will be two conning-towers, one forward and one aft, with a search-light on each. The armament is to consist of two bow torpedo tubes, a torpedo gun aft, and three 37-pounder rapid-firing guns.

A weight of 15 tons is to be carried on trial, which will be a three hours' continuous run. If on a three hours' trial the mean speed of the boat exceeds 22 knots, a premium of $1,500 will be paid, provided the boat is accepted by the Department, for each quarter of a knot in excess of 23 knots, and $2,000 for each quarter of a knot in excess of 24 knots. If the speed of the three hours' trial calculated as aforesaid falls below 22 knots a penalty of $4,000 will be exacted. If the speed on trial falls below 20 knots, the Department reserves the right to reject the boat. The contract calls for the completion of the boat in 15 months.

Covered Reservoirs.

(Abstract of paper in the *Journal* of the New England Water-Works Association, by Charles H. Swan, Boston.)

COVERED reservoirs have been used for the storage of water from periods of great antiquity. They have been constructed of various sizes and shapes, from the small cisterns supplying single dwellings, to the large reservoirs of ancient fortified cities, and of modern municipal water works.

During recent excavations at Jerusalem, many ancient reservoirs have been discovered. Those which appear to be the oldest, and of very great antiquity, were formed by sinking deep wells through the rock and then making an enlargement at the bottom to act as a collector. Second in antiquity are the cisterns with natural roofs. These were excavated in a stratum of softer rock, the overlying harder stratum serving as a roof. A third class was formed by excavating the rock and covering the opening with an arch. A fourth class, modern, were built amid the loose débris, the accumulations of the centuries, which forms a large portion of the site of the modern city. It is estimated that the ancient subterranean cisterns in the vicinity of the Temple alone contained upward of 10,000,000 gallons. One of them, known as the Great Sea, is said to have had a capacity of 2,000,000 gallons. Numerous other cisterns, some of them of large capacity, have been discovered, excavated in the rocky hills of the vicinity.

Many fortified cities of antiquity were provided with subterranean reservoirs to supply water during sieges. The ancient cisterns of Constantinople are reported to have contained a supply for 1,000,000 men during four months. Several of them are still in existence. Other ancient covered reservoirs might be mentioned, but these examples are sufficient to indicate their magnitude and importance.

The covered reservoirs of modern water-works owe their origin to the necessity for maintaining the purity of the supply when it is stored in the vicinity of large cities. The effect of covering is:

1. To protect the water from solar heat and light; thereby securing uniformity of temperature and preventing the growth of vegetation.
2. To protect the water from atmospheric impurities.
3. To prevent malicious pollution.

These three classes of evils vary in relative importance in different climates and localities.

It has for many years been recognized that water derived from certain subterranean sources is peculiarly liable to be invaded by vegetable growths upon exposure to the light and heat of the sun in open reservoirs. Examples of this action have been found in water from various geological formations, both in Europe and in the United States. Apparently, such water contains principles which do not affect its clearness or limpidity, but which promote vegetation upon exposure to the light, rendering the water unsightly, and frequently developing a disagreeable taste and odor. The examinations of the water supplies of towns now being made by the Massachusetts State Board of Health will, it is hoped, furnish an explanation of this curious fact.

An interesting illustration of the effect of excluding sunlight from a water derived from subterranean sources, and which had caused complaint, is given by Mr. G. H. Parker in a recent report, some of the details of which are as follows:

"The town of Brookline is supplied with water from a covered filter gallery. The water is pumped into two reservoirs, one of which is an iron tank supplying the high service. Complaint having been made that the water supplied from these reservoirs had an offensive taste and smell, while the water in the filter gallery, which was in darkness, remained free from any disagreeable qualities, it was deemed advisable to cover the high-service tank with a double roof, and ascertain whether the exclusion of light would prevent the development of the unpleasant changes.

"Examinations made subsequent to the covering of the tank showed that while the water in the filtering gallery continued to be clear, free from green algæ, and devoid of disagreeable taste or smell, and while the water from the open reservoir continued to show 'an abundant supply of green algæ, was slightly cloudy, and had a very strong taste and decidedly fishy smell,' the water from the high service tank, 'now completely darkened, contained only one specimen of green algæ, was now free from odor and taste, and for all practicable purposes as good as that pumped at the filter gallery.' It was concluded that the exclusion of light would be a complete remedy for the unpleasant effects, and the construction of a covered reservoir is contemplated."

Similar conclusions have been reached in England. Thomas Hawksley, the celebrated English engineer, testified in 1852 before the Select Committee on the Metropolis Water Supply Bill, that water taken from the new red sandstone was peculiarly liable to the growth of algæ if it was exposed to the sun, but that the exclusion of light and heat was a complete preventive. He also said that he had recommended covering a reservoir at Liverpool, a short time before, to avoid these unpleasant results.

The water of lakes and rivers may also be invaded by growths of algæ under favorable conditions. This growth is greatest in shallow open reservoirs, or ponds, where the water is comparatively still, and where it is exposed to a considerable elevation in temperature. In reservoirs exceeding 12 or 15 ft. in depth the growth does not appear to be so troublesome.

The danger of pollution from atmospheric impurities is greatest in the neighborhood of smoky cities. At London this was formerly the source of great annoyance. The surface of the water in reservoirs was often covered with a film of soot and dust, and if the water remained in the reservoir a sufficient time it acquired a bitter flavor.

The General Board of Health in its report in 1852 on the supply of water to the metropolis, in consideration of this trouble, and also of the fact that filtered water after exposure in open reservoirs frequently had to be strained before it could be used for domestic purposes, on account of growths of algæ in the reservoirs, arrived at the following conclusion: "Against the modern engineering practice of exposed and open reservoirs we would rather revert to the custom of the Roman engineers and recommend covering the service reservoirs and aqueducts to the utmost extent practicable."

Influenced by similar considerations, the Select Committee of the House of Commons reported a bill, which

was passed July 1, 1852, containing the following clauses: "Every reservoir within a distance in a straight line from St. Paul's Cathedral in the City of London of not more than five miles, in which water for the supply for domestic use of the metropolis or any part thereof is stored or kept by any company, shall be roofed in or otherwise covered over: Provided always, that this provision shall not extend to any reservoir the water from which is subjected by the company to efficient filtration after it is discharged from such reservoir and before it is passed into the mains or pipes of the company for distribution, or to any reservoir the whole of the water from which is distributed through distinct mains or pipes for other than domestic purposes, nor to any reservoir whatever the water stored in which shall be used exclusively for other than domestic purposes. . . . No water shall be brought or conducted within the metropolis by any company for the purpose of domestic use, otherwise than through pipes or through covered aqueducts unless the same shall be afterward filtered before distribution."

English engineers, having in mind the conditions obtaining in England, appear to regard protection against soot and dust as the most important point, although they by no means ignore the importance of protection against heat and light.

French engineers, on the other hand, seem to consider protection against solar influences as the most important. This naturally follows from the fact that French cities are much less smoky than English cities.

The atmospheric conditions in the United States resemble those of France, although there are localities in this

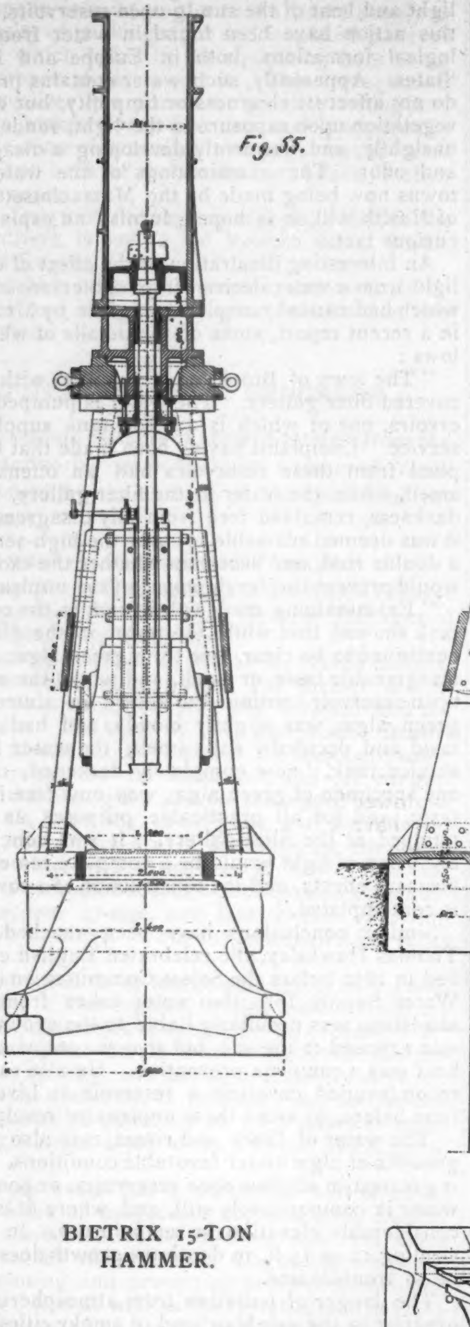


Fig. 55.

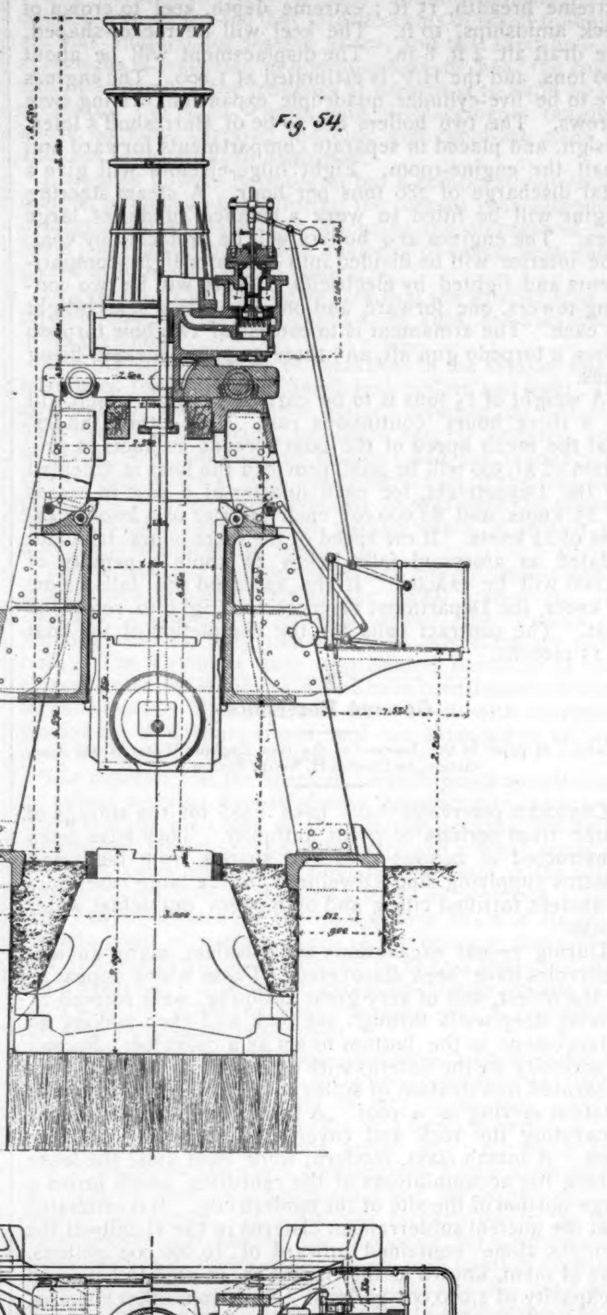


Fig. 54.

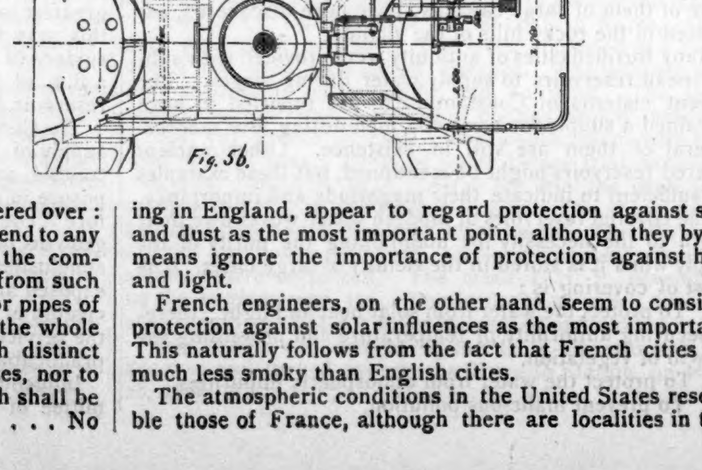


Fig. 56.

BIETRIX 15-TON HAMMER.

country which are as smoky as any in England. The need of covered reservoirs has been felt here for several years, especially since the use of ground-water as a supply and the practice of filtering have become common, and several have been constructed.

A covered reservoir does not usually present any serious difficulty to the engineer. It should be built of materials that are durable, and which are not liable to injure the quality of the water. Iron has been used for pillars, girders, or covering; but its use is to be avoided on account of its liability to corrosion. Small reservoirs may be covered with ordinary roofs or sheds; but these do not usually afford a sufficient protection against the heat. The best and most usual covering is of masonry or brickwork covered with a thin coating of asphalt to prevent the percolation of surface drainage, and by a layer of earth. The numerous covered reservoirs near London are mostly built in this way. It is usual to provide numerous ventilators.

The shape and constructive details are greatly dependent upon local conditions. The following types are common: 1. A circular reservoir covered with a flat dome. 2. A circular reservoir of larger size divided by circular walls into several annular compartments each of which is arched. 3. A rectangular reservoir divided longitudinally by straight walls into several compartments each of which is arched. 4. A reservoir covered by groined arches supported upon masonry piers. There are also variations of these types made by using iron. It is very common to make openings in the division walls thereby uniting two or more compartments. In some instances these openings are so extensive that the wall becomes virtually a series of piers.

[The paper gives a careful description of several covered reservoirs in France and Germany, which lack of space compels us to omit.]

The question as to the necessity of covering a reservoir must mainly depend upon local requirements and conditions. As a general guide it may be said that if the supply is from subterranean sources, or if it must be stored after being filtered, a covered reservoir is necessary, and that when a reservoir is amid smoky surroundings it should be covered. If the supply is from a river or lake, a covering is desirable, if the reservoir must needs be shallow. If the reservoir is deep, of large capacity, and not amid smoky surroundings, the necessity for covering diminishes and the question merges into one of cost. In the case of large storage reservoirs the expense of covering is generally prohibitory.

The best and most usual method of covering is by arches of masonry or brickwork, coated on the top with asphalt, and covered with two or three feet of earth, which may be turfed. Ventilation is important.

NOTES ON STEAM HAMMERS.

By C. Chomienne, Engineer.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Continued from page* 407.)

CHAPTER XVIII.

THE BIETRIX 15-TON HAMMER.

This single-acting hammer was built in 1883 at the Bietrix Works, St. Etienne, France, for the Loirette Forge; it is shown in the accompanying illustrations, fig. 54 being an elevation, fig. 55 a side elevation, and fig. 56 a plan. The anvil-block is independent, and rests on oakwood blocks placed below and strongly bolted together both below and above.

This hammer, especially intended for die-forging, is characterized by the use of wrought-iron legs or frames. These are four in number, having a section of 0.600 by 0.150 meter up to the slides, and of 0.550 by 0.110 meter up to the upper frame. They are joined at the lower end by a heavy shoe of cast iron resting upon a massive foundation of cut-stone masonry, and fixed to it by means of foundation bolts. On the wider faces of the frame and at one-half its height are two plates of wrought iron 0.800 by 0.080 meter, serving as cross-braces or ties. On the narrower faces are two blocks of cast iron bolted to the legs, upon which are fixed the slides made of forged steel. These frames are united together above on the inner side by cast-iron plates carrying dovetails upon which the upper frame is fixed. The space between the dovetails on these cast-iron blocks and those on the upper frame is filled by wooden keys, which secure a certain amount of elasticity and prevent breakage. At each end of the dovetails there is a lug which receives a bolt intended to unite the frame and the legs in a complete manner.

The platform, where the hammerman stands, is 2.200 meters above the ground. The distribution of steam is made by a circular valve, and the holding dogs are worked through levers by a foot-piece placed at the side of the hammerman.

The dimensions of this hammer are as follows:

Total weight of the striking parts...	15	tons.
Stroke	2.000	meters.
Diameter of the cylinder...........	0.820	meter.
Diameter of the piston-rod.........	0.300	meter.
Maximum travel of the piston-valve.	0.740	meter.
Weight of the anvil-block..........	65	tons.

The open space between the legs at the level of the ground being 3.000 meters, and the clear height under the slides being 1.600 meters, these hammers can be used both for forging and for drawing or stamping.

CHAPTER XIX.

THE CREUSOT 20-TON HAMMER.

This single-acting hammer, which is of very excellent design, is intended both for forging heavy pieces and for drawing down steel ingots; it is shown in the accompanying illustrations, fig. 57 being an elevation, fig. 58 a side elevation, fig. 59 a plan, and fig. 60 showing the cylinder and valves.

The lower frames are of cast iron, and though well separated, have great resistance to shocks; they are fixed upon the foundation block directly, and the exterior or outside foot forms a certain angle, avoiding in that way any lateral displacement. The legs are braced together at the height of the hammer by heavy wrought-iron plates, which are bolted through the frames.

The anvil-block rests upon a broad bed made of oak timbers, joined together by long bolts, and placed upon a foundation bed of beton. The anvil-block is made in two parts, of about the same width, and joined together by heavy bolts, which not only unite the two parts, but also secure the legs to the base. Each of the parts has a very wide base, and there are a number of holes in which can be placed levers to assist in moving it or placing it.

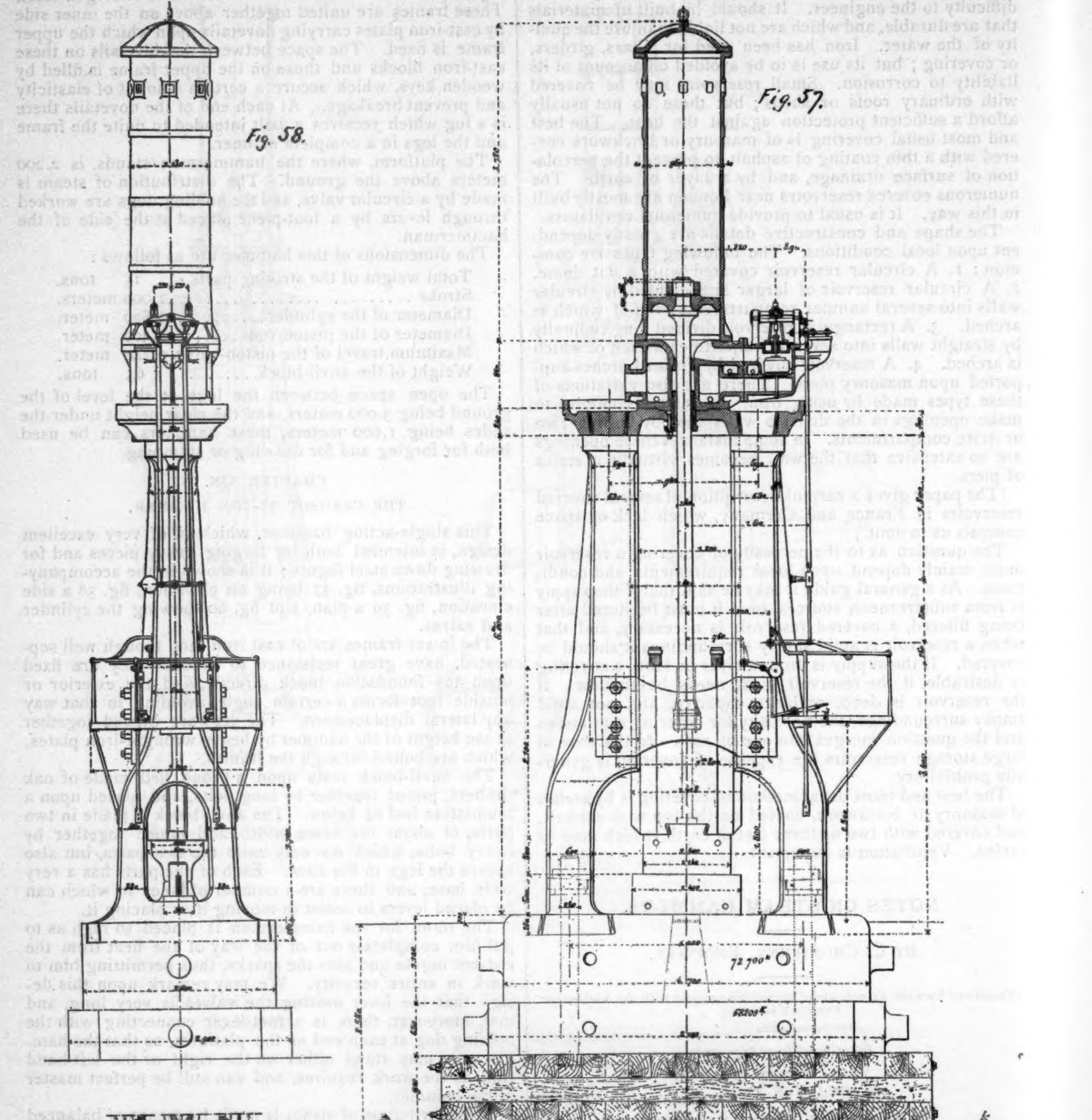
The stand for the hammerman is placed so high as to put him completely out of the way of the heat from the red-hot ingots and also the sparks, thus permitting him to work in entire security. We may remark upon this design that the lever moving the valves is very long, and that, moreover, there is a foot-lever connecting with the holding dog at each end of the platform, so that the hammerman may stand either on the right or the left-hand side, as the work requires, and can still be perfect master of the hammer.

The distribution of steam is made by means of balanced valves with double seats, as shown. These valves—usually placed in the same line, parallel to the axis of the hammer—are in this case placed upon the same line, but perpendicular to this axis. In this way the length of the steam-chest is very much reduced, and the size of the face on which it is joined to the cylinder is also very much reduced.

The piston is held to the rod by means of a cylindrical nut, over which an iron ring is sprung on hot.

The principal dimensions of this hammer are as follows:

Weight of striking part............	20	tons.
Maximum stroke..................	2.850	meters.
Diameter of cylinder	0.950	meter.
Diameter of steam-valve..........	0.175	meter.



CREUSOT 20-TON HAMMER.

Fig. 61.

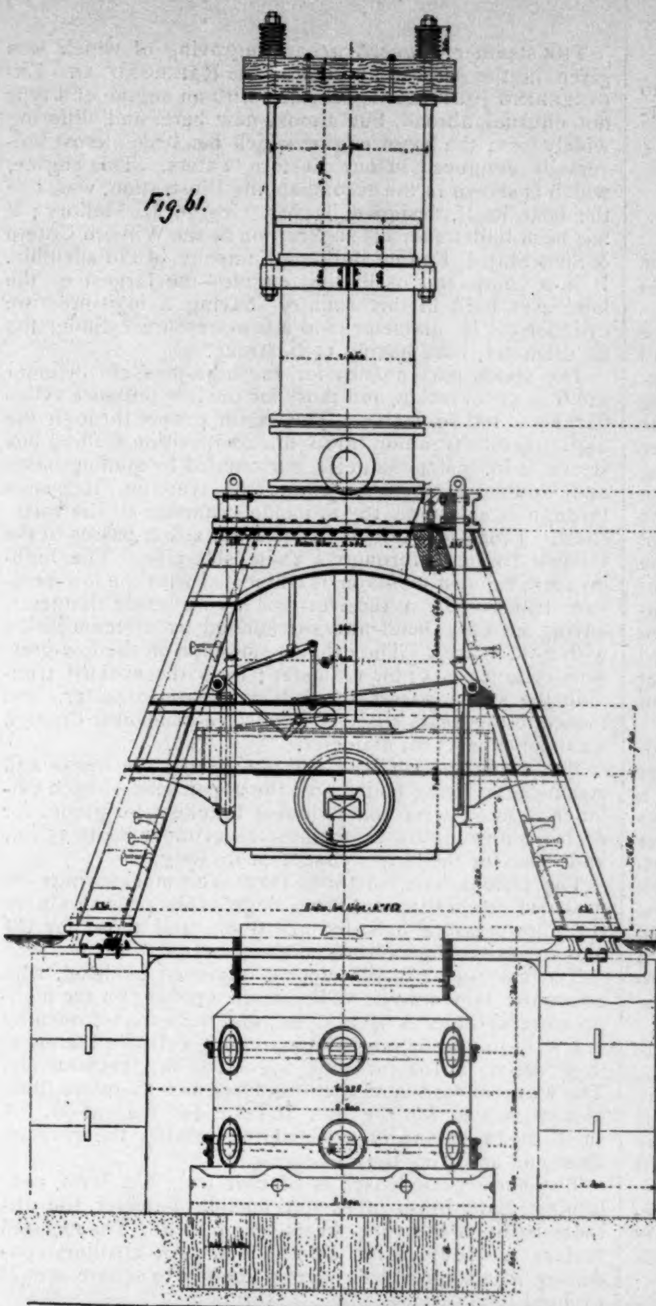
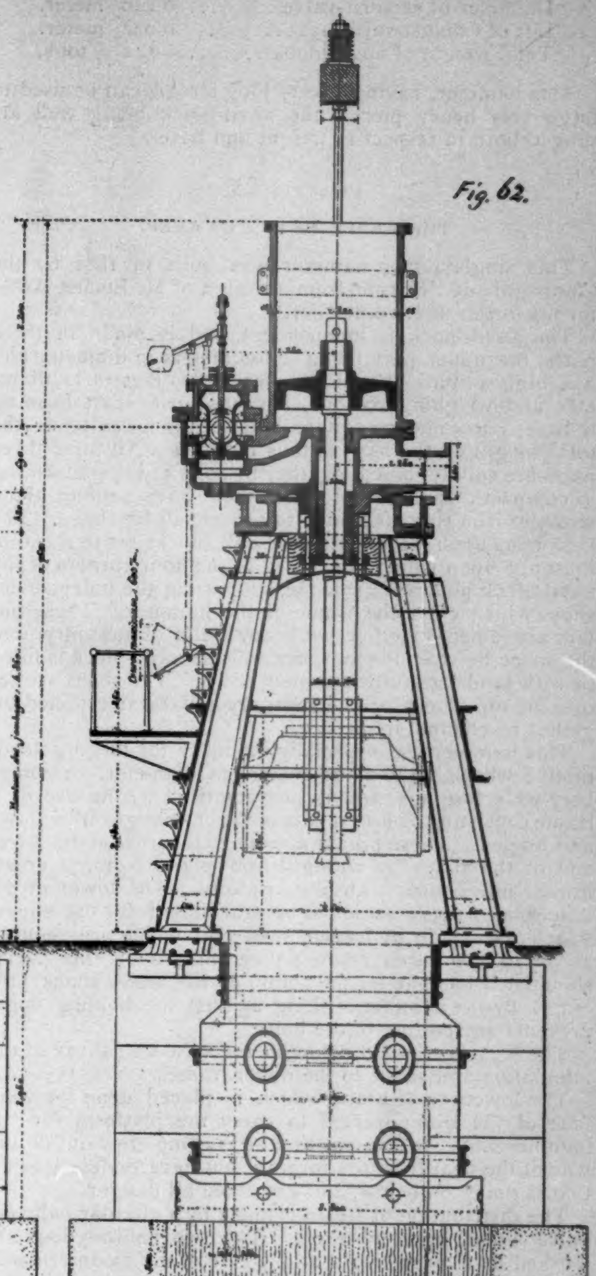


Fig. 62.



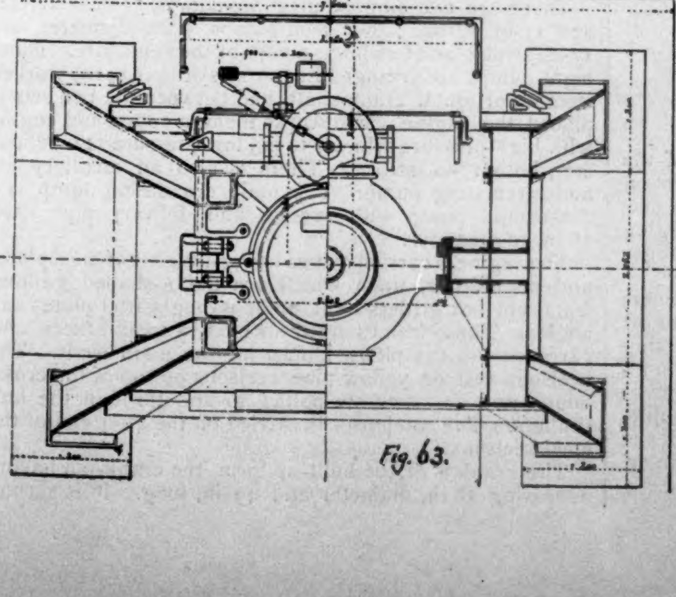


Fig. 63.

ARBEL 40-TON HAMMER.

Lift of steam-valve	0.023	meter.
Diameter of exhaust-valve	0.240	meter.
Lift of exhaust-valve	0.032	meter.
Total weight of anvil-block	141	tons.

This hammer, having a very long stroke, can be used to forge very heavy pieces, the anvil-block being well arranged both in respect to weight and base.

CHAPTER XX.

THE ARBEL 40-TON HAMMER.

This single-acting hammer was built in 1881 by the Compagnie de l'Horme, from a design of M. Lucien Arbel for his forges at Rive-de-Gier.

The anvil-block is independent, and is made in three parts, the upper part being 2.200 meters in diameter and weighing 45 tons, the middle piece 2.800 meters in diameter and weighing 46 tons, and the lower part forming a base 3.300 meters square and weighing 49 tons; the total weight of the base is thus 140 tons. All these three parts are solidly joined together by bolts and rings forming a compact whole; moreover, they have around them wrought-iron rings intended to prevent all breakage. The base rests upon a foundation of oak blocks set in a bed of masonry upon which are placed at the four corners of the anvil-block pillars of cut stone, supporting the independent shoes which carry the frame of the hammer. These pillars are joined together by heavy walls of masonry, and the space between the masonry and the anvil-block is filled in with sand carefully rammed down. The shoes are set into the top blocks of the masonry pillars and joined together by channel irons.

This hammer was especially intended for forging lcoomotive wheels up to 2.300 meters in diameter, and other very wide forgings, and is characterized by the use of a frame consisting of four pillars made of wrought-iron plates and angles. These pillars are joined together at the lower end of the slides by wrought-iron plates forming cross-braces and securing absolute rigidity. The lower cross-braces also serve as points of attachment for the slides, which are made of forged steel and which are secured above to the upper frame; they carry upon this part a shoulder, which, under the action of the heavy shock produced by the hammer striking against the holding dogs, prevents any cutting of the bolts.

The legs are bolted below to the cast-iron shoes of the foundation and above to the upper frame.

The lower cross-brace, which is placed upon the wide face of the frame, serves to carry the platform for the hammerman. In this position he is completely out of the way of the heat from the forging, but nevertheless sees all that is going on below, and can avoid all danger.

The distribution of steam is made by a circular balance-valve moved by hand-levers. The two holding dogs are worked by a lever placed at one side of the hammerman.

The principal dimensions of this hammer are as follows:

Total weight of striking mass	40	tons.
Maximum stroke	1.650	meters.
Diameter of the cylinder	1.320	meters.
Diameter of the piston-valve	0.510	meter.
Maximum stroke of valve	0.170	meter.
Weight of the anvil-block	140	tons.

The distance apart of the frames at the level of the ground being 4.820 meters one way and 2.600 meters on the other, it follows that the dies for the forgings are perfectly free, and that all the maneuvers required in forging the wheels can be made with great ease, and the changes of the dies can also be very readily made.

It will be seen that all the French and Belgian hammers described are single-acting—that is, use steam only to lift the hammer, depending upon the weight of the working parts entirely for the blow—this type being the one in almost universal use in those countries. In England, as will be seen further on, much use is made of the double-acting hammer, in which steam is used on both sides of the piston, aiding in the blow as well as lifting the hammer.

(TO BE CONTINUED.)

ENGINES OF THE STEAMER "CONNECTICUT."

THE steamer *Connecticut*, an engraving of which was given in the August number of the RAILROAD AND ENGINEERING JOURNAL, is provided with an engine of a type not unusual abroad, but almost new here, and differing widely from the beam engine which has been almost universally employed in our Eastern waters. This engine, which is shown in the accompanying illustration, was, like the boat itself, designed by Mr. George B. Mallory; it has been built under his supervision by the William Cramp & Sons Ship & Engine Building Company, of Philadelphia. It is a compound oscillating engine—the largest of the kind ever built in this country—having a high-pressure cylinder 56½ in. diameter, and a low-pressure cylinder 104 in. diameter, both having 11-ft. stroke.

The steam-port nozzles for the high-pressure cylinder are 6 × 41 in. inside, and those for the low-pressure cylinder, 8½ × 100 in. inside. The steam passes through the high-pressure trunnion through a composition stuffing-box sleeve 24 in. inside diameter, surrounded by stuffing-boxes and double air-spaces. From the trunnion it passes through a side-pipe 18 in. inside diameter to the valve-chest. From the exhaust chests the steam passes to the exhaust trunnion through a 22-in. side-pipe. The high-pressure exhaust trunnion is connected with the low-pressure trunnion by a receiver-pipe 26 in. inside diameter, having an easy bend and surrounded by a steam-jacket with 2-in. spaces. The exhaust side-pipe on the low-pressure cylinder is 33 in. diameter; from the exhaust trunnion the steam passes through a grease-extractor, and thence to the steam space in the surface-condenser through a copper-pipe 33 in. diameter.

The cylinders are cast without heads, the heads and steam-chests being bolted on; the upper head of each cylinder is fitted with heavy double brackets for guides for each piston-rod, those for the small cylinder being 15 in., and those for the large cylinder 21 in. long.

The pistons have cast-iron rings, and steel springs are provided for setting out these rings. The piston rods for the high-pressure cylinder are 9 in., and those for the low-pressure cylinder 10 in. diameter.

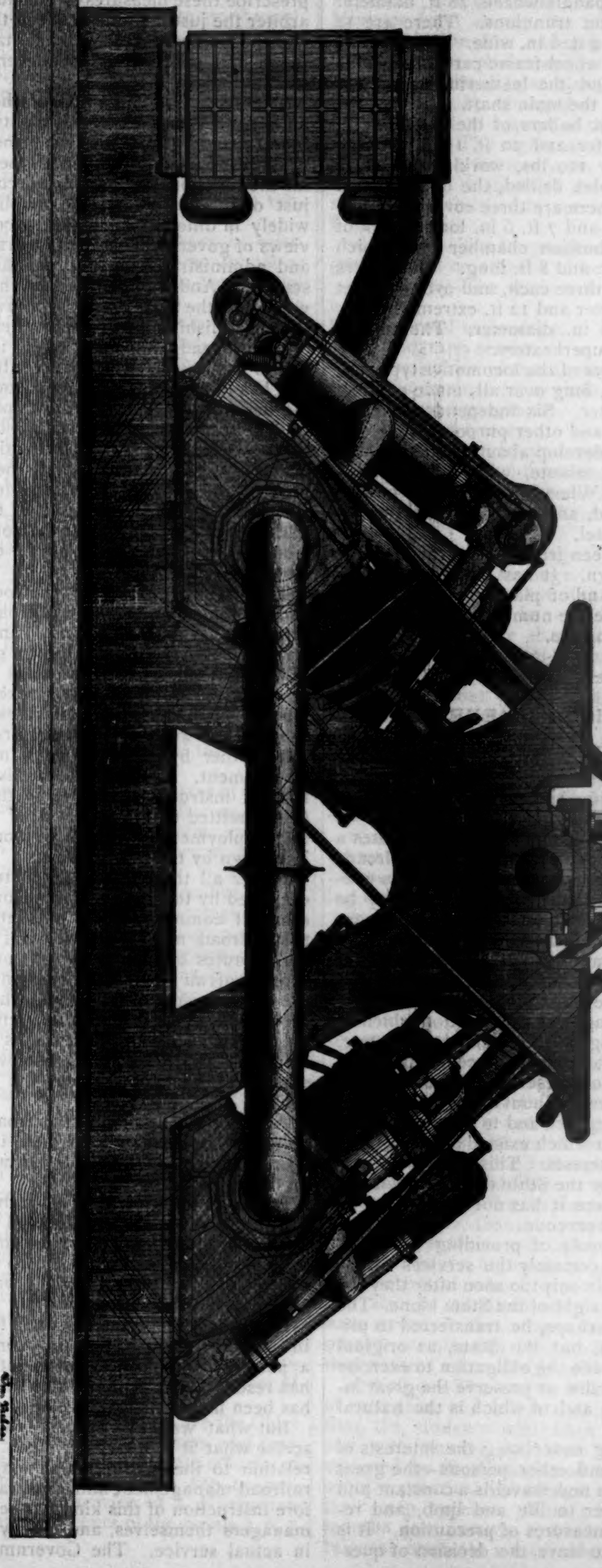
The valve-gear is Wheelock's improved gridiron, with automatic trip cut-off. The steam opening on the high-pressure cylinder is 6½ × 52 in., and the exhaust opening 11½ × 52 in., while on the low-pressure cylinder the openings are 9¾ × 102 in. and 19½ × 102 in., respectively. The valve motion is of the link type, and there are three eccentrics, two for the link and one for the cut-off. A small steam-engine is provided for working the reverse-lever and adjusting the valve-gear.

The surface-condenser is of cast iron, box form, containing 3,916 brass tubes ¾ in. outside diameter, the distance between the tube-sheets being 16 ft. The exposed surface is about 12,150 square feet. An auxiliary condenser is also provided, having about 750 square feet of exposed tube surface.

There are two single-acting air-pumps 35 in. diameter and 17-in. stroke; four feed-pumps 5 in. diameter and 17-in. stroke, and two bilge-pumps of the same size. These eight pumps are arranged in two sets of four each, worked from a horizontal crank-shaft, and between the two sets is placed the engine which works them, a compound engine with high-pressure cylinder 14 in., low-pressure 24 in. diameter, both 17-in. stroke. There is also an auxiliary air and circulating pump. The main circulating pump is a centrifugal pump with suction and delivery pipe each 16 in. in diameter.

The engine is carried by two heavy keelsons of steel plates and angle-irons, upon which are the A-shaped gallows frames of box girders built up of wrought-iron plates and angles. These frames are connected by sway-braces, and carry on top the pillow-blocks for the main shaft. The keelsons rest on yellow pine keelsons on top of the cross-floors, and are securely bolted to and through the hull timbers. The condenser is carried on the after end of the steel keelsons.

The crank is of the built-up form, the crank-pin having a bearing 18 in. diameter and 49 in. long. It is shrunk



COMPOUND OSCILLATING ENGINE FOR STEAMER "CONNECTICUT."

DESIGNED BY GEORGE B. MALLORY FOR THE PROVIDENCE & STONINGTON STEAMSHIP COMPANY.

into one crank-arm, and secured by a nut at one end and gibs at the other. The crank-arms are also shrunk on and keyed to the ends of the two shafts, each of which is 33 ft. 6 in. long, and has journals 23 and 25 in. diameter.

The boat has feathering paddle-wheels 28 ft. diameter between centers of the bucket trunnions. There are 12 buckets, each 14 ft. face and 4 ft. 6 in. wide. The buckets are of oak 4½ in. thick. The wheel-frame carries bearings for the bucket trunnions, and the feathering motion is given by eccentrics keyed on the main shaft.

Steam is furnished by six boilers of the "gunboat" type, each 12 ft. 6 in. diameter and 20 ft. 1¼ in. extreme length. These boilers carry 120 lbs. working pressure, and are of steel, all rivet-holes drilled, the outside shell ⅞ in. thick. In each boiler there are three corrugated furnaces 48 in. inside diameter and 7 ft. 6 in. long; back of the furnaces is a deep combustion chamber from which run 424 tubes 3¼ in. diameter and 8 ft. long. The boilers are arranged in two sets of three each, and over each set is a superheater 11 ft. diameter and 12 ft. extreme height, having a single flue 7 ft. 6 in. diameter. The smoke-stacks stand directly on the superheaters.

There is also a donkey-boiler of the locomotive type 7 ft. diameter of barrel and 12 ft. long over all, made of steel. It has 156 tubes 3 in. diameter. Six independent steam-pumps are provided for feed and other purposes.

This engine is expected to develop about 4,500 indicated H.P. at 25 revolutions per minute, with a full load—about 500 tons—on board. When driven at full power, 5,500 H.P. will be developed, and a speed of 19½ miles per hour obtained for the vessel.

This engine is, as will be seen from the engraving, of a very neat and compact design. It has the great advantages of economizing space and of placing all the weight low down in the vessel, while the number of parts is necessarily less than in the beam type.

A RAILROAD SCHOOL IN EUROPE.

(Note of M. Bela Ambrozovics, in the *Bulletin* of the Commission of the International Railroad Congress.)

It might be said that every railroad charter constitutes a monopoly. The reason is that functions of the railroads are extremely important, so that the public safety is concerned in their management, and their powers may be confounded with those of the State in all countries more or less subject to the encroachment of public authorities. In fact, if we inquire how railroads in their capacity of commercial enterprises differ essentially from former methods of transportation, we find that it is in this idea of monopoly. The protection against competition which is conferred upon them, the right to condemn real estate, and other privileges which have been conceded in many states are so many methods of preserving this monopoly, which would, perhaps, exist even without them, owing to the immense amount of capital required and to the understood, although not expressed, union which existed between these companies to protect their interests. This is also the case even in these countries where the State does not own any interest in railroads and where it has not aided them by subsidies or by guarantees of revenue.

Now in our view the monopoly of providing for indispensable public needs—and certainly the services of the railroads become indispensable only too soon after they are established—is properly the right of the State alone. The exercise of this right may, perhaps, be transferred to private persons or associations, but the State, as original owner of the right, cannot evade the obligation to exercise the influence necessary to secure or preserve the great interests which are concerned, and of which is the natural protector.

For instance, in everything concerning the interests of the public—both travelers and other persons—the great speed at which railroad trains now travel is a constant and unavoidable source of danger to life and limb, and requires costly and elaborate measures of precaution. It is only prudent foresight not to leave the decision of questions as to these precautions to the partial and prejudiced judgment of those who are directly interested in the expenses of construction and management of the railroad; and it is the State alone which should be authorized to prescribe these measures of precaution, holding as supreme arbiter the just medium between the interests of the public and the companies—it is the State which must be both judge and executioner whenever accidents result from criminal negligence.

The degree and method of the interference of public authority in support of the rights and obligations of the State, relative to these two principal points of view, to which are joined a number of others, depending upon how far the functions of the railroad company touch the rights, just or pretended, of the public administration, vary widely in different countries, according to the prevailing views of government, the manners, the customs, the social and administrative institutions, and many other circumstances. And it might be said that, in general, the intervention of the State is now everywhere increasing rather than diminishing in greater or less measure as the power of the railroad companies, which increases inevitably from day to day, makes itself felt by interests before untouched, and has in consequence new advocates continually appearing in favor of proper restraint upon this power.

This tendency is very marked with us in Hungary, where we find these distinctive traits of railroad companies of which we have spoken, and the result is that the functions of the railroads are considered as public services, and as such an essential part of the administration of the State; this view, however, although perhaps somewhat more marked with us, does not differ from that held in most countries in Europe.

The preliminary survey, the location, the construction, and the management of the railroads with us are regulated through special concessions granted in accordance with law, or under the provisions of a general law.

All the relations of railroads as corporations to the State, to the public, to the stockholders, and to their employés, all the fundamental rules to be observed in the construction and management, are established and regulated either by law or by rules made or approved by the Government. Even outside of this all general and detailed rules of instruction, relative to the railroad service, must be submitted to the approval of the Government. Even the employment of agents or workmen is subject to rules laid down by the Government.

Under all these conditions a strict watch and control is exercised by the agents of the Government. Thus a Government commissioner is present at all the meetings of the railroad managements, or, if this should be omitted, the minutes of the meetings must be submitted to the proper bureau; a consulting engineer is appointed to watch the construction of railroads, while the Government inspectors examine their management; these last-named officers, whose authority extends over both the railroads owned by the State and those owned by companies, possess disciplinary power over the executive officers of the roads.

All employés or agents of railroads without exception are obliged to take an official oath, in virtue of which, however, they are invested with certain limited police powers on their respective lines.

It follows naturally that when this position is once taken the State cannot stop. We have erected a wall to guard against encroachment, but we find continually breaches in this direction, and we find also that as the railroads advance on their side and in their way the Government must advance on parallel lines.

In our case a special reason is found to search for these breaches in the peculiar situation of Hungary, both from a political and economical point of view, from which it has resulted that with us the idea of State intervention has been much further developed than in other countries.

But what we have especially to speak of here is to describe what it has recently been deemed proper to do in relation to the instruction of employés for service in the railroad management and especially at stations. Heretofore instruction of this kind has been given by the railroad managers themselves, and chiefly in a practical way and in actual service. The Government has, it is true, pre-

scribed certain general rules for the degree of knowledge which persons must have before entering on this service. For over 12 years past we have adopted the principle that those railroad officers who come in contact with the public and who have to make reports should be better instructed than those who are only required to go through a certain amount of strictly routine work.

This superior knowledge involves a certain degree of education, which is usually accompanied by a corresponding elevation of sentiment. Thus for these positions it was required that the candidates must have passed through certain classes of a public high school (*gymnasium*), or of a technical school of the second class, or through a commercial or military school of the same standing, and where they had not taken such a course they were subjected to an examination.

These regulations, as we have said, have been in existence for a number of years, and there was no school or course of theoretical instruction adapted to the special needs of the candidate for railroad service. There has been in the Commercial Academy at Buda-Pesth for several years a course aided by the Government; but under the existing system this has not been successful, chiefly because there was no certainty that the students would be admitted to railroad service after they completed their course. They were sent immediately after graduating, without taking any special studies, to different stations, and it was only by their own ability, aided by such help as they might receive from the chief of the station, that they learned the indispensable knowledge and also the practical skill required for the service. After having passed the prescribed examination before an agent of the General Inspection, and after having been in service at least three months, these students could then be appointed permanent employés, but there was no obligation on the part of the companies to give them positions.

Such are the principal features of the system heretofore followed in this matter of appointing employés for the service of railroads—that is, to all positions where the technical knowledge of an engineer was not required. This system, however, was found to be full of imperfections, and did not serve well the interests either of the railroad service or of the State.

Thanks to the energy of the present Minister of Public Works and Communications, M. Gabriel de Baross, it has been replaced by another, based upon a scientific and uniform course of instruction and made obligatory at once on the students and the companies.

Under this system there has been established at Buda-Pesth, with the concurrence of the railroad companies, a course of instruction for employés in the management and the commercial service of the lines. The organization of this course was prescribed in a system of rules, dated December 21, 1886, the formal document being signed by the representatives of all the chief railroad companies—ten in number—and approved by the Minister.

We give below the full text of these regulations, with the exception of the first article, which is merely a formal repetition of what we have said in the preceding paragraph:

RULES FOR THE RAILROAD SCHOOL.

Article 2.—The course of instruction is under the immediate supervision of a commission, the head of which is a Secretary of the Ministry of Public Works, and which is composed of the Chief of the Department of Railroads, the Chief of the interested section of the said ministry, a delegate appointed by the Minister of Public Instruction, a delegate from the General Bureau of Inspection of Railroads, and a delegate from the management of each one of the railroad companies interested. This Commission will establish rules under which it will exercise its direction; which rules must be approved by the Minister of Public Works.

Article 3.—The agents of this Commission are the Chief Administrator, the Secretary, and the professors who may be appointed, and who will all be subordinate officers of the Commission. As professors, no person can be employed who is not actively in the service of a Hungarian railroad, with the exception of teachers of the points 5, 6, 7 and 9 named in Article 7.

Article 4.—The Chief Administrator—who in all cases must be chosen from among the professors—as well as the professors and other instructors, shall be appointed by the Minister of Public Work, on the nomination of the Commission. The Secretary shall be appointed by the same Minister from among the officers now employed in his bureau. It must be understood that the Chief Administrator and the professors in accepting their appointment contract to remain in service for at least three years; they can, however, be changed or removed by the Minister of Public Works on request of the Commission.

Article 5.—The rights and the duties of the Administrator and the Secretary, as well as those of the professors, and the relations of the latter to the Administrator, shall be established by special rules to be made by the Commission.

Article 6.—The language of the course is to be Hungarian; and no other is to be used.

Article 7.—The studies to be included in the course are:

1. Railroad technology.
2. Telegraph service.
3. The service of management, properly so called.
4. The commercial or traffic service.
5. Railroad geography.
6. Railroad history.
7. Laws and legislation concerning railroads.
8. Commercial arithmetic and railroad accounts.
9. Knowledge of different class of merchandise.

In addition to these there may be added as optional studies:

1. The German language.
2. The French language.

The degree and extent of the instruction in these different branches shall be established in a programme or course prepared by the Commission after consultation with the professors, and approved by the Ministry.

Article 8.—There shall be three classes of students:

1. The regular public students, including the students recommended by the railroad companies, and also voluntary students who attend the lessons regularly throughout the year. If the number of the first class exceed that fixed by the Commission, their admission may be limited, the number sent by each company to be in proportion to its contribution for the expenses of the course.

2. The private students are those who are already either permanently or temporarily in the active service of the railroads, and who at the beginning of the course or during the year are designated by their managements for admission to the final examination of the course.

3. Special public students are those who, being actively in the service of the railroads, only desire to study certain subjects in order to increase their knowledge, but without being under any obligations to attend the final examination; at the close of the course they receive a simple certificate of attendance.

As regular public students, or as private students only, such persons can be admitted as have taken the regular school course prescribed heretofore, and have attained the age of 18 years. They must in addition have their physical health and strength certified to by the Chief Surgeon of one of the railroads. They must submit to an examination for admission, the conditions of which will be established by the Supervisory Commission. It is provided, however, that this examination will not be required from those students who have passed successfully the final examination of a high school (*gymnasium*), or of a second-class technical school, or a commercial academy. There will also be admitted without examination persons who have served in the army or the territorial militia and have passed examination for an officer's commission, provided they possess a knowledge of the Hungarian language.

Article 9.—The course will commence on September 1 of each year, and will last ten months. At the end of this time the students who have attended lessons diligently and with success, and have the proper certificates, are assigned by the Commission to the different railroads, to acquire practical knowledge and to serve on trial and at their own expense. This trial service is to last three months continuously, and when it is completed successfully the students are admitted to the final examination.

Those regular public students, however, who have been admitted on recommendation of the railroad companies, and who have a certificate that they have already been in active service at least three months before beginning the course, may be admitted at once to the final examination. The private students, on the other hand, can only be admitted to the final examination after having been in active service at least 13 months.

The examinations are made by special commissions, which include a President named by the Minister, an officer of the general inspection, two members of the Supervisory Commission, and the professor. When an employé of one of the railroads is examined, it is always necessary that the representative of that railroad on the Supervisory Commission shall be one of the examining committee. In addition, each railroad company is entitled when its employés are examined to send two delegates to represent it. These delegates will not only have a right to ask questions of the candidate, but they will have also a vote in deciding the result, and the candidate will not be considered to have passed unless two of the three representatives of his company concur.

Other members of the Supervisory Commission have also the right to be present at the examinations and ask questions; but they will not have the right to vote on the final decision.

Regular public students and private students who fail to pass the final examination on one or more subjects can, by the permission of the Minister, be admitted to a second examination; but if they fail on this no further examination will be allowed.

The regulations for the examinations will be made by the Supervisory Commission, with the approval of the Minister.

Article 10.—Certificates of success will be recognized by all the railroad companies in the following manner:

1. Persons furnished with these certificates will not be obliged to undergo the examinations for telegraph service or commercial service which have been heretofore required.

2. After October 1, 1889, no person can be appointed to positions in these branches of the service who have not one of these certificates of examination.

The railroad companies, nevertheless, have reserved the right to judge of the practical knowledge of those who have received certificates by appointing them temporarily for three months; at the end of that time the company may require them to pass a special examination in the rules and instructions especially required by local circumstances on that particular line. These supplementary examinations will be under the control of the Supervisory Commission, and due notice of time and place shall be given. From October 1, 1888, the special examinations for telegraph and commercial service, heretofore in use, will be discontinued.

Article 11.—The library of the Ministry of Public Works will be open to professors and students in this course, and in addition a library of technical books and a museum will be established, especially for the use of the course. The Minister will cause to be transferred to the museum all the means of instruction—instruments, apparatus, models, books, drawings, etc.—which were provided for the use of the experimental course and remain in the charge of the Commercial Academy at Buda-Pesth. The Minister and the railroad companies further agree to provide such instruments, models, plans, etc., as may be found necessary for the museum, and to transfer them to it. The Supervisory Commission will also make arrangements with the railroads having stations and workshops at Buda-Pesth, under which the students will be able to acquire practical knowledge and receive practical lessons under the directions of the professors.

Article 12.—The regular public students and the extraordinary students will be required to pay a fee of 70 florins ($26) yearly. All these fees will be applied for the benefit of the school. The examination fee is fixed at 10 florins ($3.70) for each person; the latter amounts to be applied to pay the expenses of the Examining Committee.

Article 13.—All the expenses of the course, including the salaries of the Director, the Secretary, and the professors; heating, lighting, and care of buildings, etc.—in general, all personal and material expenses—shall be paid in equal shares by the Ministry of Public Works and the railroad companies, including the State Railroads. The half which is payable by the railroads will be divided among them in proportion to the mileage on their lines. The annual amount required will be fixed by the Supervisory Commission, subject to the approval of the Minister; the railroads are required to pay their proportion quarterly. At the end of the year a full statement of accounts, including statements of all receipts and expenses, will be prepared and published. Should any surplus remain, it will be returned to the contributors.

All the regulations which have been given are now in full operation, the rules of the Commission having been established, the professors appointed, and the actual course of instruction having begun, September 3, 1887. The most interesting point in the detailed rules is that each of the professors is required to write during his first year's service a book of instruction on the subject which is assigned to him.

Thus it is that the plan for which a simple wish was expressed in the Congress at Milan has already become an actual fact in Hungary—a consummation for which we hardly dared dream three years ago.

Thus we see in the Hungarian system a happy combination of theory and practice, which appears to provide for all exigencies which may arise, and which has also been so prepared as to conciliate all the interests concerned to make friends of both sides and to disarm those who were at first opposed to it. We see also the strong hand of the State placed upon one of the most important questions which has been presented in railroad management.

It appears to us that this system has a claim for serious consideration and that it merits careful and thorough trial in other countries, with such modifications as may be indicated by the special circumstances of each nation.

Electric Light Plant on the Steamer "Connecticut."

THE new steamer *Connecticut* of the Providence & Stonington Steamship Company's line is lighted throughout with electric lights, the entire plant having been furnished by the United States Electric Lighting Company of New York, under the supervision of Mr. George B. Mallory, the engineer who designed the vessel. The object kept in view in this case was to make the plant a representative one of this kind, and, if possible, better than anything which had before been put on a passenger boat, and the utmost care was used in all the arrangements.

The dynamos used are of the pattern adopted by the United States Company, and are shown in the accompanying illustration, fig. 1 being a front view, and fig. 2 an end view. These dynamos are run by engines of the Brotherhood three-cylinder type, each capable of delivering 45 H.P., and arranged to run at a speed of about 950 revolutions per minute. This high speed permits the coupling of the engine direct to the dynamo shaft, without the use of gearing or pulleys, thus making an extremely compact design. The connection is made by means of an ingenious flexible coupling, especially designed for this purpose, and great stiffness and stability is obtained by

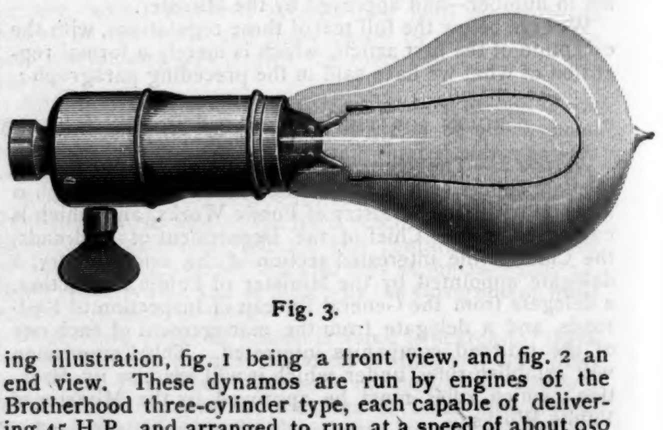


Fig. 3.

having both engine and dynamo fastened to the same bed-plate. This arrangement further secures economy of space and weight, and very little noise in running.

In order to avoid any possible annoyance to the passengers, the machinery is located in the hold forward, and in putting it in place every precaution has been taken to provide against vibration, and against the humming which is so often complained of with electric light plants. The foundations are composed of two layers of 4-in. yellow pine planks securely fastened to the keelson; a layer of felt is placed between the two layers of plank and another one between the upper layer of plank and the iron bed-plate of the machinery.

The boot is wired for 800 lights of 16 candle-power, which are distributed on a dozen different circuits. The lights are of the incandescent type usually employed by this company, and one of them is shown in fig. 3. The main wire of each of the circuits starts from the main switch-board of the dynamo room, and at this switch-board the two dynamos, each of 400 light capacity, are coupled in parallel, each dynamo main having an ampère-meter in circuit to show the load. On the same board there is also placed a Cardew volt-meter and the rheostats. There are also in the engine-room duplicates of all these instruments, so that the engineer can at all times tell whether the man who is running the dynamos is properly attending to his duties; as a further precaution an indicator is placed in the state-room of the Chief Engineer, so arranged that at any time in the night, by merely turning a switch, he can tell whether the plant is being properly cared for.

The 800 lights are distributed over every portion of the boat, not only in the cabins but in the engine-rooms, on deck, etc., and, in fact, the whole boat is supplied with these lights. The greatest care has been given to every detail of the wiring system in order to provide against and overcome the many difficulties attendant on maintaining the insulations of an electric light system on ship-board at a high point; also to provide against any unforeseen difficulty which may arise. A very high insulation wire has been used throughout, and all the wires used below deck have been encased in lead, then covered by wooden moldings. The wiring is entirely concealed, none of it being visible in any part of the boat outside of the engine-room.

The safety devices, lamp-sockets, switches, etc, have all been carefully designed for this special plant, and in designing them pains has been taken to prevent the exposure of anything which may interfere with or disfigure the decorations of the boat. Care has also been taken to so arrange the system that it will require as little attention as possible while in operation, and the power required from the engines is governed by the number of lights in use.

The plant is now practically completed, and will shortly be subjected to thorough and careful tests.

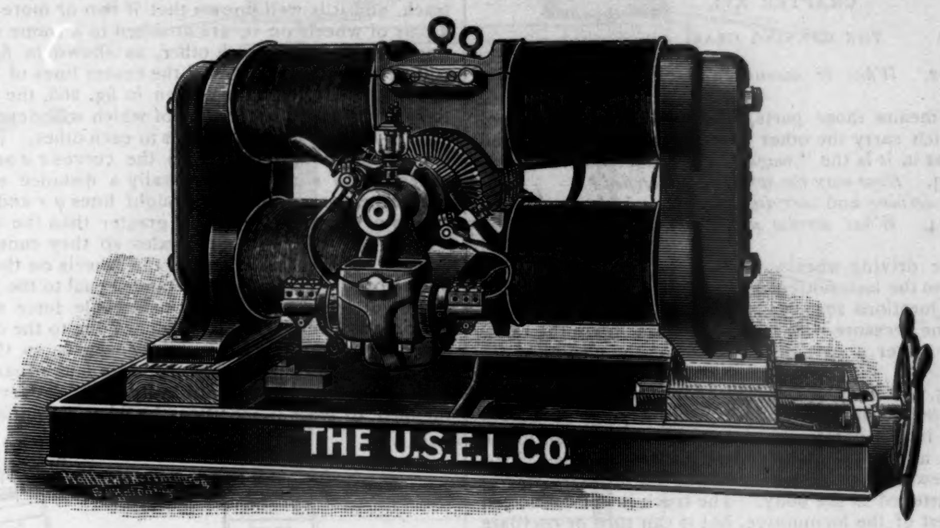


Fig. 1.

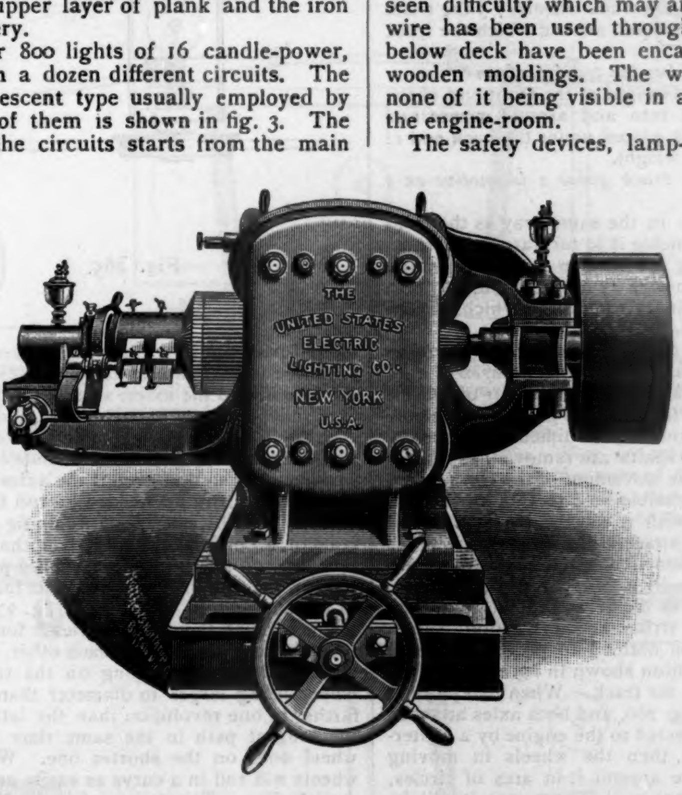


Fig. 2.

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

BY M. N. FORNEY.

(*Continued from page 425.*)

CHAPTER XVI.

THE RUNNING GEAR.

QUESTION 422. *What is meant by the running gear of a locomotive?*

Answer. It means those parts, such as the wheels, axles, and frames, which carry the other parts of the engine. As the Germans express it, it is the "*wagon*" of the locomotive.

QUESTION 423. *How may the wheels be classified?*

Answer. As *driving* and *carrying* or *truck wheels.*

QUESTION 424. *What service must the driving-wheels perform?*

Answer. The driving-wheels, as indicated by their name, "drive" or move the locomotive on the track, as was explained in answer to Questions 274, 275, and 276. As their adhesion depends upon the pressure with which they bear upon the rails, they must carry either a part or the whole of the weight of the engine.

QUESTION 425. *What is a "truck" of a locomotive?*

Answer. A *truck* consists of one or more pairs of wheels which are held in a separate frame, which is connected to the locomotive by a flexible connection—usually a *king-bolt* or *center-pin*—somewhat as the front axle of an ordinary wagon or carriage is fastened to the body. The truck is not connected rigidly to the rest of the locomotive, but it can turn or oscillate about the king-bolt, so that the axles can assume positions which approximate to that of radii of the curves of the track. In Plates III, IV, and V, 6 6 are the truck wheels, 7 5 the truck frame, and 9 8, Plate IV, the center-pin, around which the truck frame turns.

QUESTION 426. *What service does the truck perform?*

Answer. It usually carries the weight of the front end of the locomotive, and also guides it into and around curves and *switches.** Sometimes a truck is placed under the back end of a locomotive to carry part of its weight.

QUESTION 427. *How does a truck guide a locomotive on a curved track?*

Answer. It does it very much in the same way as the front wheels of an ordinary wagon enable it to turn around corners —that is, the truck wheels being attached to a separate frame, which is connected to the locomotive by a center-pin, can turn just as the front axle of an ordinary wagon can which is connected to the body by a kingbolt.

QUESTION 428. *Why are two pairs of wheels usually used on a locomotive truck instead of one, as on an ordinary wagon?*

Answer. Because it is necessary to have one pair of wheels guide the other. In a wagon the front axle is guided by the pole or shafts. Nearly every one knows the difficulty of moving such a vehicle when the pole or shafts are removed, especially if it be pushed from behind. The movement of the front axle is then uncontrolled, and it is impossible to direct its movement. The same thing would occur with a locomotive if a single pair of wheels were used and attached in the same way as the front axle of a wagon. Thus if a single pair of wheels was connected to a locomotive by a center-pin, *s*, fig. 263, so that the axle would be free to move around this pin, then if one of the wheels should strike an obstruction, say a stone, *a*, fig. 265, there would be nothing to prevent the axle from being thrown into the position shown in fig. 264, and the wheels would be liable to leave the track. When two pairs of wheels are used, as shown in fig. 266, and both axles attached to the same frame, which is connected to the engine by a center-pin, *s*, between the two axles, then the wheels in moving round the center-pin must move around it in arcs of circles, *m n*, *m n*, described from the center *s*. These arcs, it will be observed, cross the rails. Now, if the wheels should move in the direction indicated by the arcs, the flange of one of them would come in contact with the rail and prevent it from moving any farther. It is, therefore, evident that wheels arranged in that way can only move about the center-pin as far as the curvature of the track will permit. Trucks are sometimes used with only one pair of wheels, but the center-pin is then placed some distance behind the center of the axle, or in the same relation to it that the center *s* is to the axle *a a'*, in fig. 266. It is evident, then, that if the frame for such a truck turns around the center-pin, the wheels must move across the track in the same way as represented by the arcs *m n*, in fig. 266. The construction and operation of trucks with a single pair of wheels will be more fully explained hereafter.

* A switch is a movable pair of rails, by which a locomotive is enabled to run from one track to another.

QUESTION 429. *Why will a locomotive run around curves easier if the front axles are attached to a truck frame which is connected to the locomotive by a flexible connection?*

Answer. Because the truck axles can then assume positions which conform very nearly to the radii of the curves of the track, and it is well known that if two or more axles, each with a pair of wheels on it, are attached to a frame with their center lines parallel with each other, as shown in fig. 267, they will roll in a straight line, but if the center lines of the axles are inclined to each other, as shown in fig. 268, the tendency will be to roll in a curve, the radius of which will depend upon the degree of inclination of the axles to each other. In order to make the wheels in fig. 267 roll on the curves *c d* and *a b*, it will be necessary to slide them laterally a distance equal to that between the curves and the straight lines *q r* and *o n*, and as the length of the outside curve is greater than the inside one, if the wheels are fastened to the axles so they cannot turn on them and roll on the curves, either the wheels on the inside or those on the outside must slip a distance equal to the difference in the length of the two rails. Considerable force will therefore be required to overcome the resistance due to the combined lateral and circumferential sliding of the wheels, so that more power will be needed to make them roll in a curve than is necessary to make them roll in a straight line. If, however, the axles are inclined to each other, then the wheels will naturally roll on a

Fig. 263.

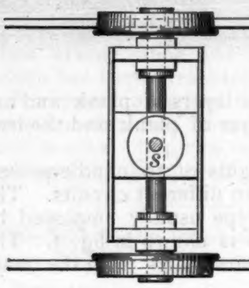


Fig. 264.

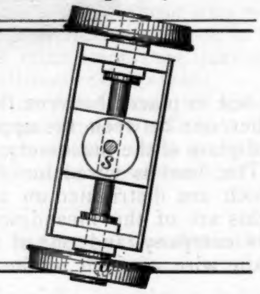
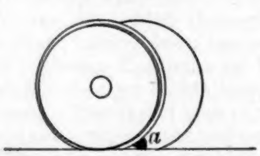


Fig. 265.



curved path, and it will not be necessary to slide them sideways to make them conform to such a path. But if the wheels are all attached to the axles, so that those on the same axle cannot turn independently of each other, and are all of the same diameter, then either the inside or the outside ones must slip, because the path in which the outside ones roll is longer than the inside curve, so that even if the axles are inclined to each other more power will be needed to roll the truck in a curved path than to roll the wheels shown in fig. 267 in a straight line. A cone or a portion of a cone, like that shown in fig. 269, will, however, of itself roll in a curved path. It will do the same thing if the middle is cut away, as indicated by the dotted lines in fig. 269 and in full lines in fig. 270. If now the wheels are made so that their peripheries * form portions of a cone and the axles are inclined to each other, as shown in fig. 271, then there will be no slipping on the track, because the outside wheel, being larger in diameter than the inside one, advances farther in one revolution than the latter does, and thus rolls on the longest path in the same time that the inside or smaller wheel does on the shorter one. When this is the case, such wheels will roll in a curve as easily as those in fig. 267 will in a straight line. The degree of inclination of the axles and of the sides of the cone must, however, vary with the radius of the curve. But if the axles are parallel to each other, and the wheels conical, as represented in fig. 272, they will not roll either in a straight line or in a curve without great difficulty, because if they roll in a straight line, the wheels on one side being larger in diameter than those on the other, either the larger or the smaller ones must slip on the path in which they roll. If they roll on a curve, then each pair of wheels has a

* The periphery is the outside surface on which the wheel rolls. This part of a wheel is usually called the "*tread.*"

tendency to roll in a curve independent of the other, and therefore the wheels must slip laterally, if both pairs roll on the same track. Thus, suppose two pairs of wheels, *a*, *a'* and *b*, *b'*, fig. 271, to be made conical and attached to a frame so that their axles are parallel to each other. Each pair of such wheels will then have a tendency to roll in circular paths, *a' i*, *a h*, and *b' k*, *b j*, the centers of which are at *m* and *n*, or at the apices of the cones of which their peripheries form a part. If they are made to roll in circular paths, *c d*, *e f*, described from a center *g*, then each pair of wheels must slip laterally over the space between the paths *a' i*, *a h*, in which they would naturally roll and that in which they are made to roll. Thus the wheel *a* would slide laterally the distance between the curve *a h* and *a f*, and *a'* that between *a' i* and *a d*; *b* would slide from *b j* to *b f*, and *b'* from *b' k* to *b' d*. It will thus be seen that in order that two pairs of wheels may roll with equal ease in a straight line and in curves, the wheels in the one case must be of equal diameters and the axles parallel, and in the other case the wheels must be of unequal diameters and their axles be *radial** to the curve. This is equally true of any number of pairs of wheels. If we have three, four, or any number of axles, with wheels all attached to the same frame, if their axles are parallel, and the wheels of the same diameter, they will roll in a straight line; but if their wheels are conical and their axles radial, they will roll in a curve.

Fig. 266.

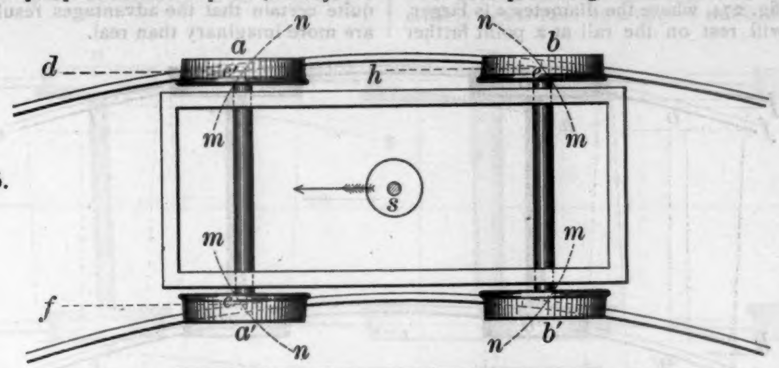


Fig. 267.

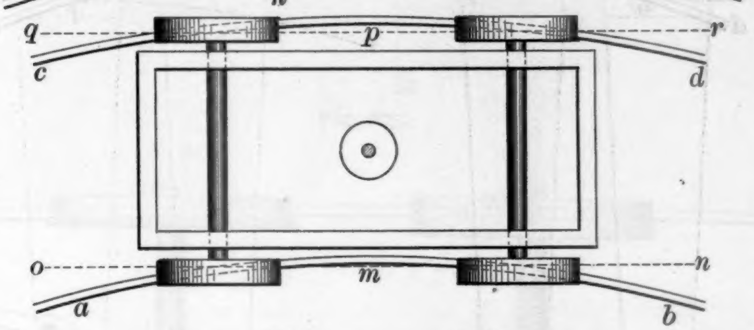


Fig. 268.

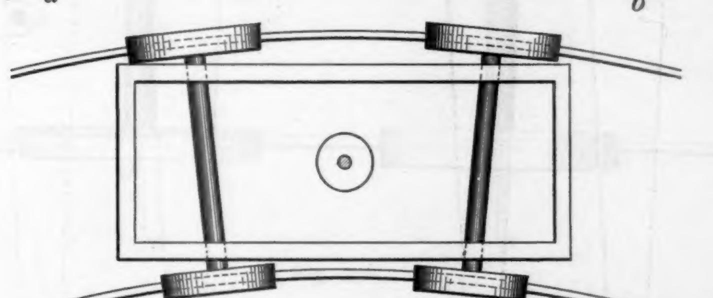


Fig. 270.

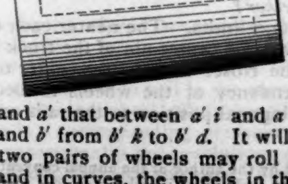


Fig. 269.

For the preceding reasons it is therefore sufficiently obvious that if a locomotive is to run on both straight and curved tracks, on the former the wheels should be of the same diameter and the axles parallel, and on the latter the wheels should be conical and the axles radial.

QUESTION 430. *How are wheels made so that on curves they will act as though they were of the conical form described and on a straight track all be of the same diameters?*

Answer. The periphery or tread of each wheel is made conical, but of the same size as the other, and with the small diameters of the cones outside, as shown in fig. 273. The flanges are then put closer together than the rails, so that there will be some space or end play, as it is called, between the flanges and the rails as shown at *s s'*. On a straight track, if the position of

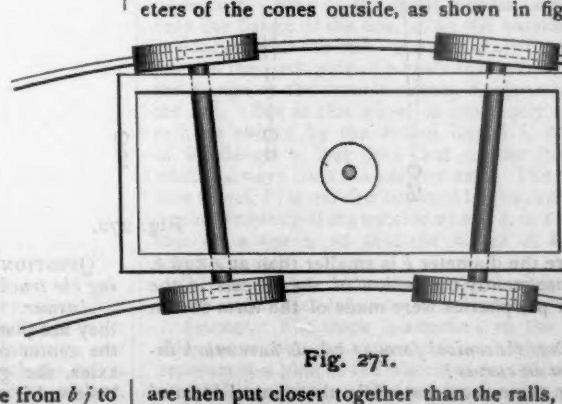


Fig. 271.

* That is, that their center lines incline toward each other, and if extended far enough would meet at the center of the curve.

the wheels on the rails is such that their two flanges are equally distant from the rails, as shown in fig. 273, then obviously at the points of contact with the rails or on the lines *a* and *b* the wheels are of the same diameter. But in running on a curved track, the wheels, as has been shown, will roll toward the outer rail of the curve. The flange *c*—supposing it to be at the outside of the curve—will therefore roll toward the rail, and consequently the outside wheel will rest on the rail at a point nearer the flange, as shown in fig. 274, where the diameter *a* is larger, and the inside wheel *b* will rest on the rail at a point farther wheels to roll in a curve. It has also been proved by experiment that when the axles are parallel to each other the influence of the conical form of the wheels diminishes as the distance between the axles increases,* so that at the usual distance apart of the driving-axles of locomotives and of truck axles of locomotives and cars, the effect of the conical form of the wheels is almost, if not quite, inappreciable. Besides this, the conicity of the treads of wheels is rapidly worn away, so that it seems quite certain that the advantages resulting from coning-wheels are more imaginary than real.

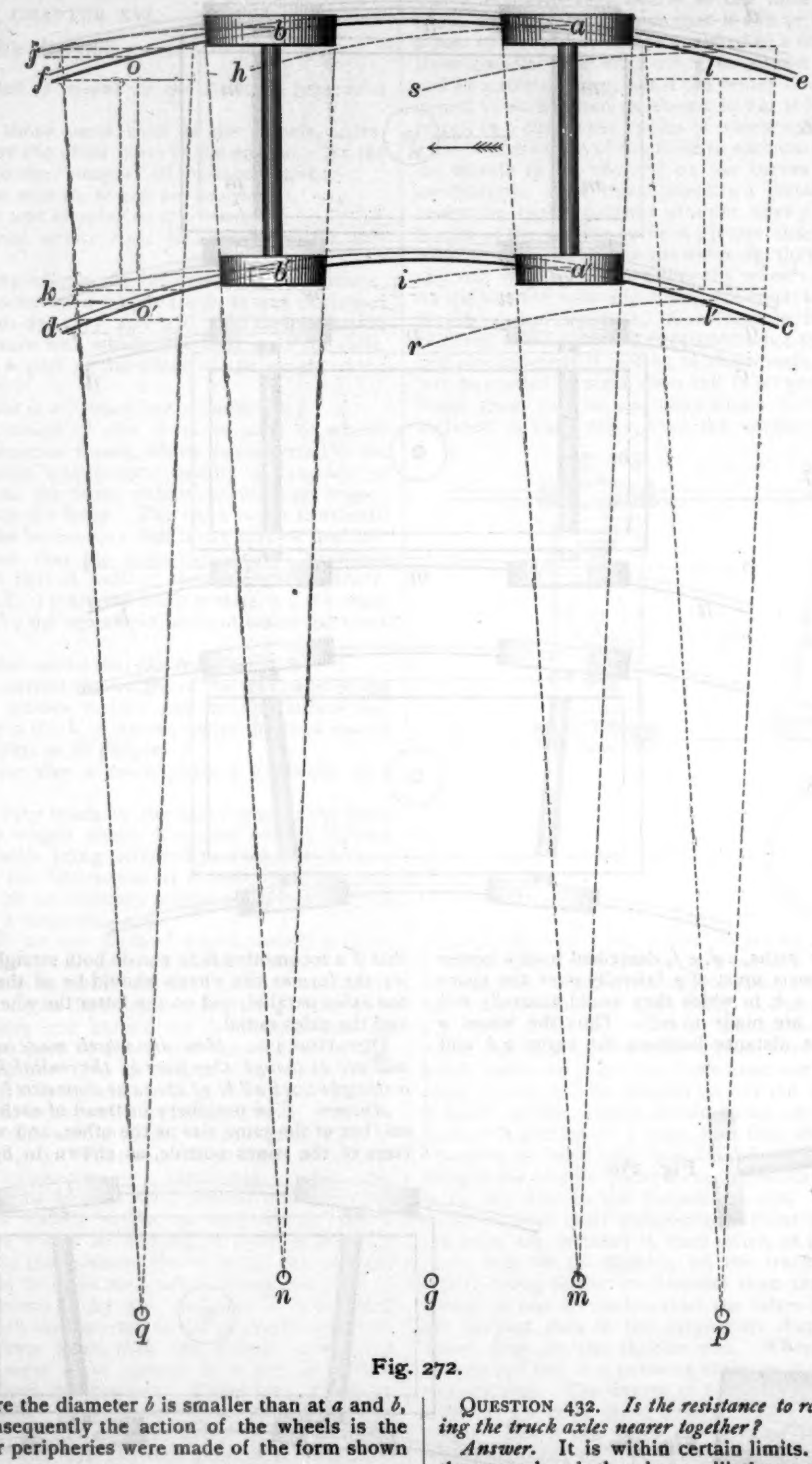


Fig. 272.

from the flange where the diameter *b* is smaller than at *a* and *b*, in fig. 273; and consequently the action of the wheels is the same as though their peripheries were made of the form shown in fig. 270.

QUESTION 431. *Does the conical form of wheels have much influence on their action on curves?*

Answer. No; for the reason that while the conical form of the wheels will cause a single pair on one axle to roll in a curved path, if the axles of two pairs of such wheels are held parallel to each other, as they are in a locomotive or truck frame, the conical form has very little influence to cause the

QUESTION 432. *Is the resistance to rolling diminished by placing the truck axles nearer together?*

Answer. It is within certain limits. The nearer each other they are placed, the closer will the center-pin of the truck be to the center of the axles. The closer it is to the center of the axles, the greater is the tendency of the wheels to become "slewed," or to assume a diagonal position to the rails as rep-

* This was shown in a paper read by the author at the annual convention of the Master Car Builders' Association, held in 1884, and which was published in the report of the proceedings of the convention of that year.

resented in fig. 264, which increases the resistance and also the danger of running off the track. The increase of resistance from this cause, after the axles reach a certain distance from each other, is greater than the decrease from a closer approximation to the position of radii. In ordinary locomotives it is necessary to place the truck wheels from 5 ft. 6 in. to 6 ft. 6 in. apart, in order to get the cylinders between them in a horizontal position. This distance apart works very well in ordinary practice.

shown, the lateral slip of the wheels is then greater than when they are nearer together. It is also obvious that if the wheels are parallel with the rails there will be no abrasive action of the flanges, but that the greater the angle at which the wheels stand to the rails the harder will the flanges rub against the rails, and the greater will be the flange friction. With the aid of geometry, it can very easily be proved that the farther apart two parallel axles are, the greater will be the angle of the wheels to the rails on a curved track, and therefore, the greater

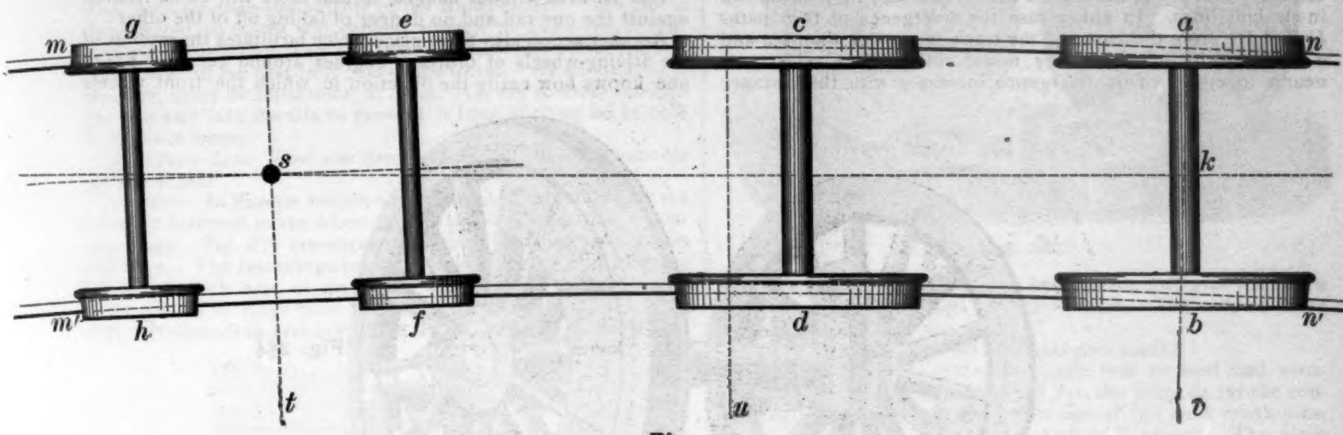


Fig. 275.

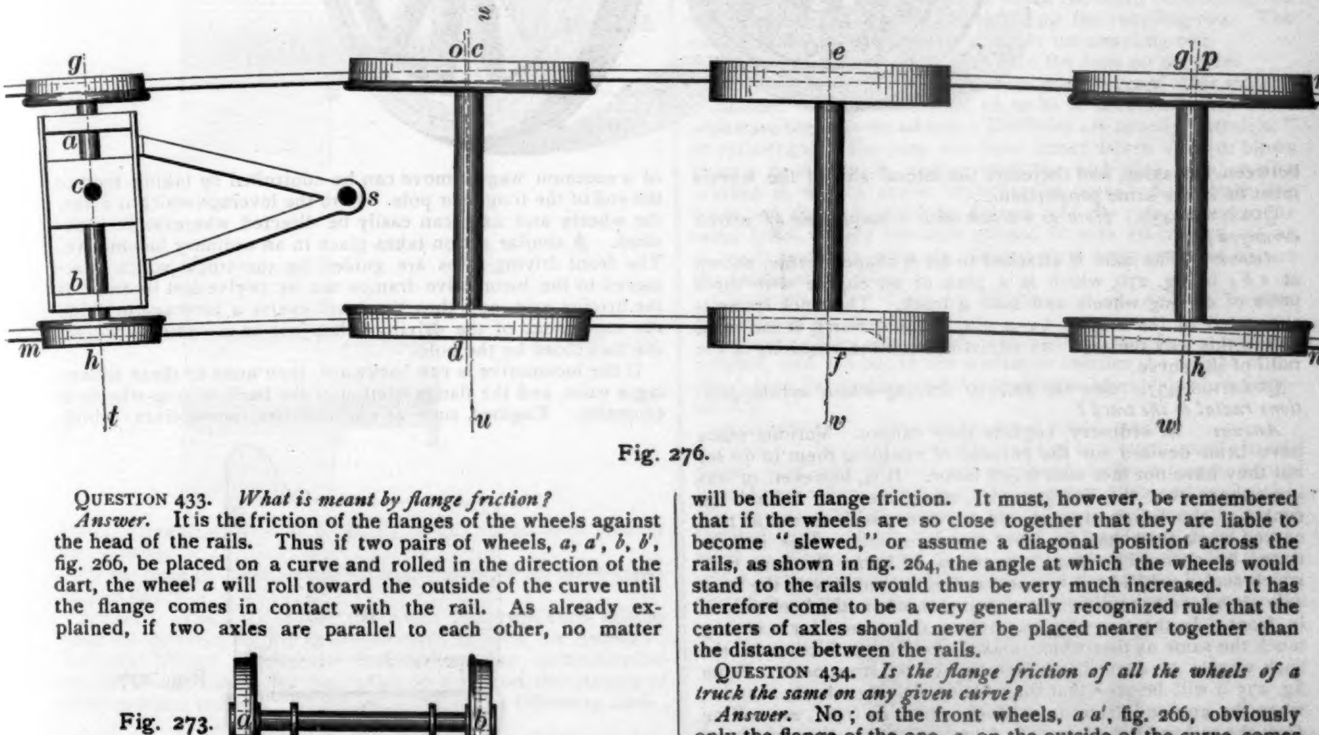


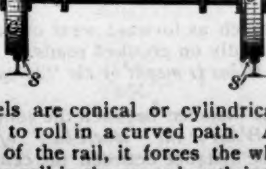
Fig. 276.

QUESTION 433. *What is meant by flange friction?*

Answer. It is the friction of the flanges of the wheels against the head of the rails. Thus if two pairs of wheels, *a*, *a'*, *b*, *b'*, fig. 266, be placed on a curve and rolled in the direction of the dart, the wheel *a* will roll toward the outside of the curve until the flange comes in contact with the rail. As already explained, if two axles are parallel to each other, no matter

Fig. 273.

Fig. 274.



whether the wheels are conical or cylindrical, they must slip laterally in order to roll in a curved path. As the flange must follow the curve of the rail, it forces the wheel laterally, and thus compels it to roll in the curved path into which the rail is bent. As the wheel offers considerable resistance to sliding, there is a corresponding pressure of the flange against the rail, and consequently the revolutions of the wheel produce an abrasive action between the two. This action is obviously increased with the distance between the axles, because, as has been

will be their flange friction. It must, however, be remembered that if the wheels are so close together that they are liable to become "slewed," or assume a diagonal position across the rails, as shown in fig. 264, the angle at which the wheels would stand to the rails would thus be very much increased. It has therefore come to be a very generally recognized rule that the centers of axles should never be placed nearer together than the distance between the rails.

QUESTION 434. *Is the flange friction of all the wheels of a truck the same on any given curve?*

Answer. No; of the front wheels, *a a'*, fig. 266, obviously only the flange of the one, *a*, on the outside of the curve comes in contact with the rail. As the centrifugal force of the engine presses the back pair of wheels toward the outside of the curve, the flange of the outside wheel, *b*, alone comes in contact with the rail. But as this wheel is constantly rolling *away* from the rail, as shown by the dotted line *h b*, obviously the friction of its flange is less than that of the front outside wheel, *a*, which always rolls *toward* the rail. The flange of the back inside wheel, *b'*, is carried outward by the centrifugal force and also by the tendency of the outside wheel, *b*, to roll on its largest diameter on a curve, so that the flange of *b'* will not ordinarily touch the rail.

QUESTION 435. *How does a truck allow the axles of a locomotive to adjust themselves to the curvature of the track?*

Answer. The truck is attached to the locomotive by a flexible connection or center-pin, *s*, as shown in fig. 275 (which represents a plan of the wheels of an ordinary locomotive), from which it can be seen that the truck axles *e f* and *g h*, instead of remaining parallel to the driving-axles *a b* and *c d*, will, by turning around the center-pin, *s*, adjust themselves to the curvature so as to approximate as closely to radii as is possible for two axles which are that distance apart and are held parallel to each

other. Of course, the farther apart they are the greater will be their divergence from the position of radii, and whether the tread of the wheels be cylindrical or conical, the farther apart their axles are the greater will be the divergence of the paths in which they would naturally roll from that of the curve of the track on which they must roll. Thus, if the axles were twice as far apart as they are represented in fig. 272, and in the position shown in the dotted lines *l l'* and *o o'*, the wheels, if they are conical, would then naturally roll in curves drawn from the centers *p* and *q*. If the wheels are cylindrical, they would roll in straight lines. In either case the divergence of their paths *l s* and *l' r* from the curve of the track is greater than *a h* and *a' i*, the paths in which they would roll if their axles were nearer together. This divergence increases with the distance between the axles, and therefore the lateral slip of the wheels must be in the same proportion.

QUESTION 436. *How is a truck with a single pair of wheels arranged?*

Answer. The axle is attached to an A-shaped frame, shown at *a b s* in fig. 276, which is a plan of an engine with three pairs of driving-wheels and such a truck. The truck frame is connected to the engine by a pin, *s*, about which it can turn, and in this way the axle can adjust itself to the positions of the radii of the curve.

QUESTION 437. *Can the axles of driving-wheels assume positions radial to the track?*

Answer. In ordinary engines they cannot. Various plans have been devised for the purpose of enabling them to do so, but they have not met with much favor. It is, however, of less importance that the driving axles, when they are behind the center of the locomotive, should assume positions radial to a curved track than that the front wheels should. This is illustrated by a common road wagon, as all know the ease with which such a vehicle can turn a corner if we run it with the front axle ahead, and the difficulty of doing so when the back axle is in front. In the case of a locomotive, the reason for it is very much the same as that which makes the flange friction of the back wheels of a truck less than that of the front ones. From fig. 275 it will be seen that the outside driving-wheels, *a* and *c*, when the engine is running with the truck in front, are rolling *from* the rail and not against it. As stated before, the centrifugal force of the engine when in motion has a tendency to throw the wheels toward the outside of the curve. It will also be noticed that the front driving-axle is near the center of that portion of the curve which lies between the center, *s*, of the truck and the center, *k*, of the back axle. If it were in the middle, between them, it would be exactly radial to the curve; being near the middle, it approximates closely to that position, and therefore the flange friction of its wheels is very slight. It will be noticed that if the flange of the back or trailing-wheel, *b*, on the inside of the curve was not kept away from the rail, it would roll toward and impinge against that rail, and that the flange of the front driving-wheel, *d*, will come in contact with the inside rail before that on the back wheel can touch it. For this reason, and also on account of the effect of the centrifugal force exerted on the engine and the tendency of the wheels to roll on their largest diameters, the flange of the inside back wheel is kept out of contact with the rail, and as the back wheel, *a*, on the outside of the curve rolls away from the rail there is very little friction of the flanges of the back driving-wheels.

It will also be noticed from fig. 275, that if the radius of the curve is very short, the bend of the rails between the back pair of driving-wheels, *a b*, and the center of the truck is so great that the inside rail will press hard against the flange of the front or main driving-wheel, *d*, next that rail. This of course produces a great deal of friction, and if the curve is excessively short the flange will mount on top of the rail, and the tread of the opposite wheel will fall off from its rail. For this reason the center-pin of the truck is sometimes arranged so that it can move laterally—that is, crosswise of the track. The front wheels of locomotives are also sometimes made with wide "flat" tires—that is, tires without flanges, so that there will be no friction against the one rail and no danger of falling off of the other.

Another action also takes place which facilitates the motion of the driving-wheels of ordinary engines around curves. Every one knows how easily the direction in which the front wheels of a common wagon move can be controlled by taking hold of the end of the tongue or pole. With the leverage which it gives, the wheels and axle can easily be directed wherever it is desired. A similar action takes place in an ordinary locomotive. The front driving-axles are guided by the truck, which is attached to the locomotive frames ten or twelve feet in front of the driving-axle, and thus the truck exerts a leverage to guide the movement of the driving-axles, just as a common wagon can be guided by the pole.

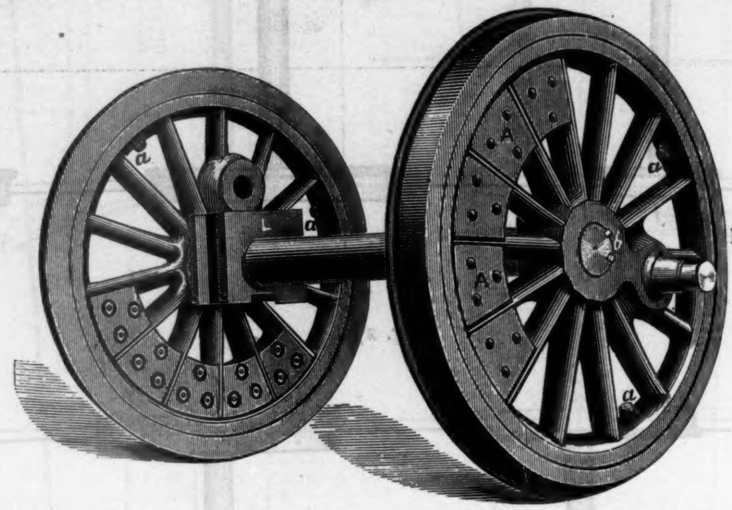


Fig. 254.

If the locomotive is run backward, then none of these advantages exist, and the flange friction of the back driving-wheels is excessive. Engines, such as construction locomotives, which run backward as much as forward wear out the flanges of the back wheels very rapidly on crooked roads.

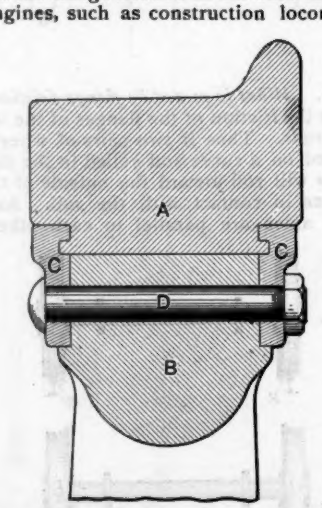


Fig. 277.

QUESTION 438. *What is meant by the "spread" of the wheels or axles?*

Answer. It is the distance between the centers of the axles.

QUESTION 439. *What is the "wheel-base" of a locomotive?*

Answer. It is the distance between the centers of the front and back or trailing-wheels. On ordinary engines, such as that illustrated in Plate III, it is the distance from the center of the front truck to the center of the back driving-wheels.

QUESTION 440. *How are the driving-wheels of locomotives constructed?*

Answer. In this country they are made of cast iron with

wrought-iron or steel tires around the outside. Fig. 254 represents a perspective view of a pair of locomotive wheels and axle. The central portion of the wheel—that is, the hub, spokes, and rim, are cast in one piece. Usually the hub and the rim, and sometimes the spokes, are cast hollow. The central portion of the wheel—that is, the part which is made of cast iron, is called the *wheel-center*. In Europe the wheel-centers are generally made of wrought iron.

QUESTION 441. *How are the tires fastened on the wheel-centers?*

Answer. The insides of the tires are usually turned out somewhat smaller than the outside of the wheel-center. The tire is then heated so that it will expand enough to go on the center. It is then cooled off, and the contraction of the metal binds it firmly around the cast-iron part of the wheel. As an additional security, bolts or set-screws, *a*, *a*, fig. 254, are screwed through the rim and into the tire to prevent it from slipping off in case it becomes loose.

QUESTION 442. *How are tires held on the wheels in case the former break?*

Answer. In Europe and on some railroads in this country the tires are fastened to the wheel-centers by what are called retaining rings. Fig. 277 represents a section of a tire fastened in this way. The fastenings consist of flat rings, *A A*, which are placed on each side of the wheel and tire and fastened with bolts, *D*. The rings have annular projections, *C C*, which fit into corresponding grooves in the tires. In case the tire should

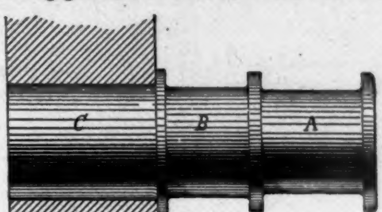


Fig. 278.

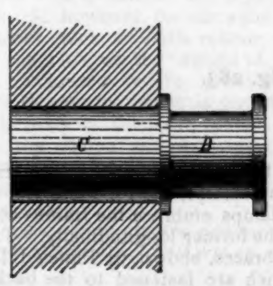


Fig. 279.

break, these rings hold it on in its position, and thus prevent an accident.

QUESTION 443. *Are there any standard sizes for the inside diameters of tires?*

Answer. Yes. To avoid the great inconvenience arising from the diversity in the *inside diameters* of tires, the American Railway Master Mechanics' Association has recommended standard dimensions for the inside of tires and the outside of driving-wheel centers. These are given in the following table:

STANDARD DIMENSIONS FOR DRIVING-WHEEL CENTERS AND TIRES.

Outside Diameter of Wheel-Centers.	Allowance for Shrinkage of Tire.	Inside Diameter of Tires.
38 in.	0.040 in.	37.960 in.
44 "	0.047 "	43.953 "
50 "	0.053 "	49.947 "
56 "	0.060 "	55.940 "
62 "	0.066 "	61.934 "
66 "	0.070 "	65.930 "

QUESTION 444. *How are the driving-wheels fastened on the axles?*

Answer. The hubs are accurately bored out to receive the axles, and the latter are turned off so as to fit the hole bored in the wheel. The axles are then forced into the wheel by a powerful pressure produced either with a hydraulic or screw press, made for the purpose. In order to prevent the strain upon the crank-pins from turning the wheels upon the axle,

Fig. 280. Fig. 281.

Fig. 282.

they are keyed fast with square keys driven into grooves cut in the axle and in the wheel to receive them. The ends of these keys are shown at *b*, fig. 254.

QUESTION 445. *How are the crank-pins made?*

Answer. They are made of wrought iron or steel and accurately turned to the size required for the journals for the connecting-rods. Fig. 278 represents one of the main crank-pins, and fig. 279 a back pin for an American engine. The main pin has two journals, one, *A*, to which the main connecting-rod is attached, and the other, *B*, receiving the coupling-rod. The back pin has only one journal, *B*, for the coupling-rod.

The collars on the crank-pins hold the rods on the pins.

QUESTION 446. *How are the crank-pins fastened to the wheels?*

Answer. They are turned so as to fit accurately into holes which are bored in the wheels. The holes are usually "straight" or cylindrical. The pins are then either driven in with blows from a heavy weight swung from the end of a rope, or else pressed in with a screw or hydraulic press. Sometimes the holes are bored tapered or conical and the pins turned to the same form. They are then ground in with emery and oil, so as to fit perfectly, and are secured by a large nut and key on the inside of the wheel.

QUESTION 447. *What are the pieces A, A, fig. 254, between the spokes of the wheel for?*

Answer. They are called *counterbalance weights*, or counterweights, and are put in the wheels to balance the weight of the crank-pins, connecting-rods, and pistons, as explained in Chapter XV.

QUESTION 448. *How are the truck wheels made?*

Answer. They are generally made of cast iron, usually in one piece. Figs. 280, 281 and 282 represent the most common form of cast-iron wheel which is used for locomotive and car trucks. Fig. 28 is a view of the front or outside of a wheel, fig. 281 of the back side, and fig. 282 is a wheel with a part of it cut away, so as to show a section of it. It will be seen that the plates which form the center of the wheel and the ribs on the back are curved in form. They are made in this shape so that when the

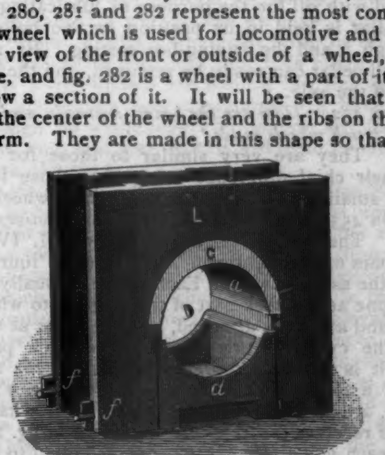


Fig. 284

wheel is cast and contracts in cooling, the plates and ribs can spring somewhat without being strained to a dangerous degree.

The tread of the wheel is hardened by a process called *chilling*. This is done by pouring the melted cast iron into a mould of the form of the tread of the wheel. The mould for the tread is also made of cast iron, but being cold cools the melted iron very suddenly, and thus hardens it somewhat as steel is hardened when it is heated and plunged into cold water.*

* It is only certain kinds of cast iron which will be hardened in this way, or will "*chill*," as it is called. The cause to which this chilling property is due is not known.

QUESTION 449. *What other kinds of wheels are used for car and locomotive trucks?*

Answer. A variety of wheels with steel tires are used for locomotive and car trucks. The wheel-centers are made of cast iron or wrought iron, or compressed paper held between two wrought-iron plates. The tires are fastened to the centers—or they should be fastened—with some kind of retaining rings.

QUESTION 450. *What is the shape of the tread and flange of a car and locomotive wheel?*

Answer. Fig. 283 represents the standard form for the treads and flanges of car and locomotive wheels which has been adopted by the Master Car Builders' and the Master Mechanics' Associations.

QUESTION 451. *On what part of the axle does the weight of the engine rest?*

Answer. It rests on what are called the *journals*, which are just inside of the wheels. These journals turn on brass bearings, called *journal-bearings*, which resist the friction of the revolving axle. The bearings are held in cast-iron or cast-steel boxes, called *journal-boxes.* One of these is shown at *L*, in fig. 254, and also separately, in fig. 284, in which *C* is the journal bearing and *d* the *oil-cellar.* The latter is a receptacle underneath the axle which is filled with wool or cotton waste which is saturated with oil for the purpose of lubricating the journal. The oil-cellar is held in its position by two bolts. *f, f*, which pass through it and the driving-box casting. By removing the bolts the oil-cellar can easily be removed, and the box can then be taken off the axle.

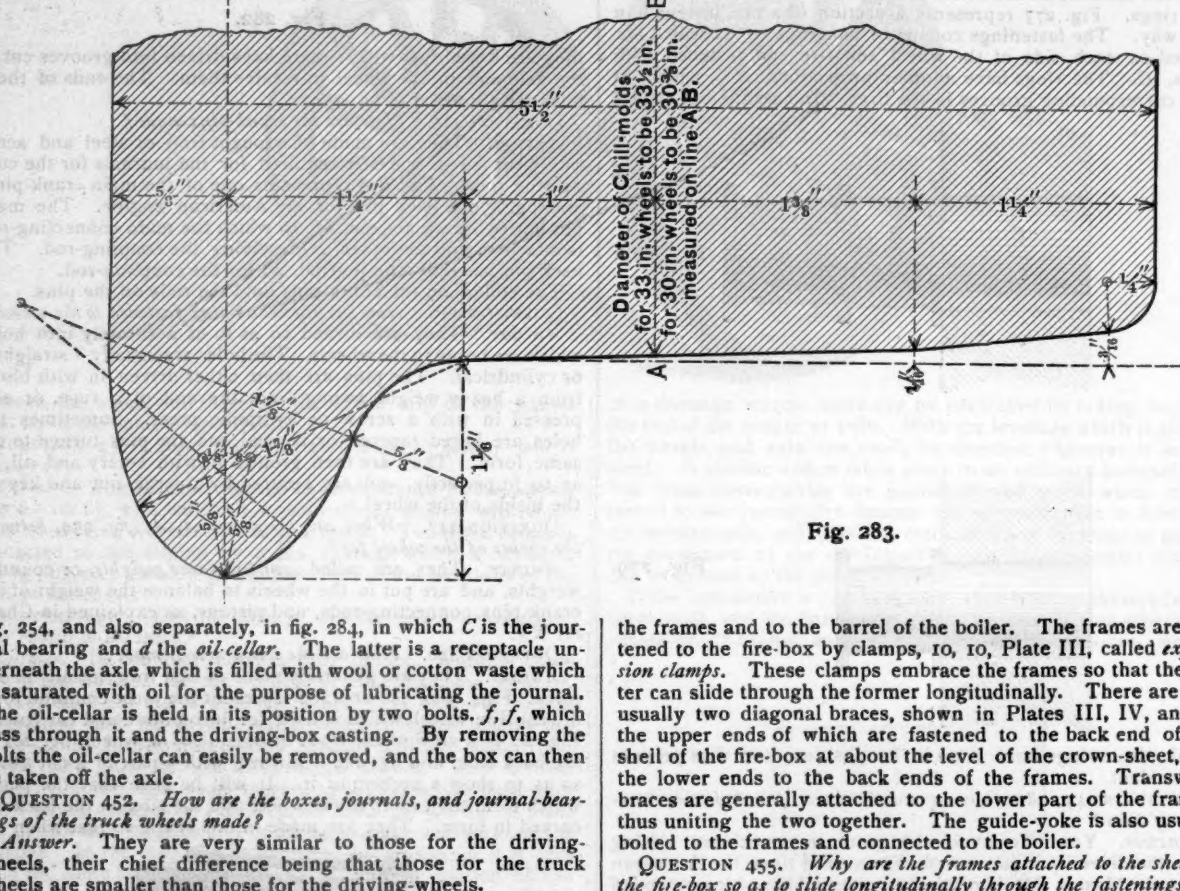


Fig. 283.

QUESTION 452. *How are the boxes, journals, and journal-bearings of the truck wheels made?*

Answer. They are very similar to those for the driving-wheels, their chief difference being that those for the truck wheels are smaller than those for the driving-wheels.

QUESTION 453. *How are the frames for locomotives constructed?*

Answer. The frames, 32, 32, 32, Plates III, IV, and V, are made of bars of wrought iron from three to four inches thick and about the same in width. Each frame is usually made in two parts, the one at the back part of the engine, to which the driving-boxes and axles are attached, and the other at the front end to which the cylinders are bolted. The back part, or main frame, as it is called, is represented in figs. 285 and 286, and consists of a top bar, *H H*, to which pieces, *a, a', b, b'*, called *frame-legs*, are welded. Two of these form what is called a *jaw*, which receives the axle-box, as shown in fig. 286. To the bottom of each jaw a *clamp, c*, fig. 285, is bolted to hold the two legs together. The two legs, *a* and *b'*, are united by a brace, *d d*, bolted to the legs. A brace, *m*, unites the back end of the frame with the leg *b*, and is welded to each.

The front part of each frame consists of a single bar, *e*, which is bolted to the back end, as represented in figs. 285 and 286, which show the construction clearer than any description would. The front bar is shown plainly in Plates IV and V—the back end only is shown in figs. 285 and 286. These front bars extend forward to the front end of the engine, and a heavy timber, called a *bumper-timber*, extends across from one to the other and is bolted to each of them, as shown in Plates III, IV, and V. This timber is intended to receive the shock or blow when the locomotive runs against any object, such as a car. The *cow-catcher* or *pilot*, 38, 38, is fastened to this timber.

The front bar of the frames also has usually two lugs or projections forged on it, shown in Plate IV, between which the cylinders are attached. The latter are securely held in their position by wedges, which are driven in between the lugs and the cylinder castings.

The frames, as already stated, are in this country made of wrought-iron forged bars, and are accurately planed off over their whole surface. In Europe they are made of rolled-iron plates.

QUESTION 454. *How are the frames fastened to the boiler?*

Answer. As already stated, they are fastened to the cylinders with wedges and bolts, and as the cylinders are bolted to the smoke-box, the frames are thus rigidly attached to the front end of the boiler. In order to strengthen those portions of the frames which extend beyond the front of the smoke-box and to which the bumper-timber is attached, diagonal braces, shown in Plates III, IV, and V, are bolted both to the timber and to each of the frames at their lower ends. The upper ends are bolted to the smoke-box. Other braces are also fastened to the frames and to the barrel of the boiler. The frames are fastened to the fire-box by clamps, 10, 10, Plate III, called *expansion clamps.* These clamps embrace the frames so that the latter can slide through the former longitudinally. There are also usually two diagonal braces, shown in Plates III, IV, and V, the upper ends of which are fastened to the back end of the shell of the fire-box at about the level of the crown-sheet, and the lower ends to the back ends of the frames. Transverse braces are generally attached to the lower part of the frames, thus uniting the two together. The guide-yoke is also usually bolted to the frames and connected to the boiler.

QUESTION 455. *Why are the frames attached to the shell of the fire-box so as to slide longitudinally through the fastenings?*

Answer. Because when the boiler becomes heated it expands, and if it could not move independently of the frames its expansion would create a great strain on both itself and the frames. The fastenings to the fire-box are therefore made so that the frames can move freely through them lengthwise, but in no other direction.

QUESTION 456. *How much more will a boiler expand than the frames in getting up steam?*

Answer. From $\frac{1}{4}$ to $\frac{5}{16}$ of an inch.

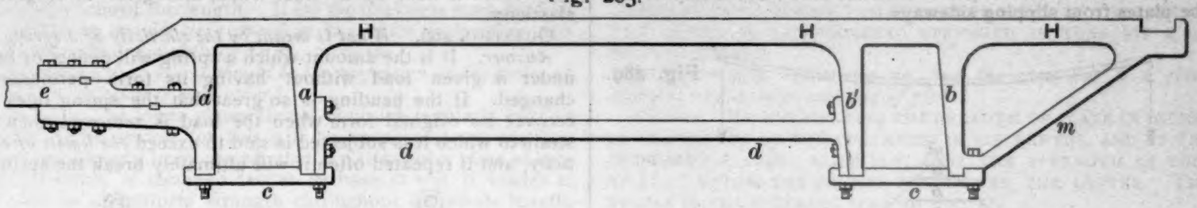
QUESTION 457. *Why is it necessary to support the engine on springs?*

Answer. Because,* however well a road may be kept up, there will always be shocks in running over it; these occur at the rail joints and especially when the ballasting of the ties is not quite perfect. These shocks affect the wheels first, and by them are transferred through the axle-boxes to the frame, the engine, and the boiler. The faster the locomotive runs, the more powerful do they become, and therefore the more destructive to the engine and road, and consequently the faster a locomotive has to run the more perfect should be the arrangement of the springs.

* This answer and much of the material referring to springs has been translated from "Die Schule des Locomotivführers," by Messrs. J. Brosius and R. Koch.

If we strike repeatedly with a hammer on a rail, the latter is soon destroyed, while it can bear without damage a much greater weight than the hammer lying quietly on it. The axles, axle-boxes, and wheels strike like a hammer on the rails at each shock, while the shock of the rest of the parts of the engine first reaches and bends the springs, but on the rails has only the effect of a load greater than usual resting on them. Another comparison will make still plainer the lessening by the

Fig. 285.



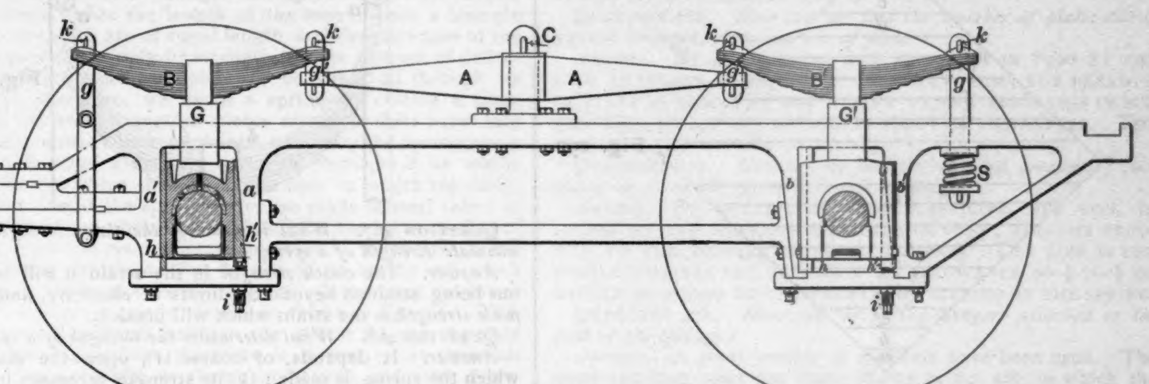


Fig. 286.

springs of the injurious effect which the weight of the boiler, etc., exercises on the rails.

A light blow with a hammer on a pane of glass is sufficient to shatter it. If, however, on the pane of glass is laid some elastic substance, such as india-rubber, and we strike on that, the force of the blow or the weight of the hammer must be considerably increased before producing the above-named effect. If the locomotive boiler is put in place of the hammer, the springs in place of the india-rubber, and the rails in place of the glass, the comparison will agree with the case above. From this consideration it will be seen how important it is to make the weights of the axles, axle-boxes, and wheels as light as possible.

QUESTION 458. *How are the driving-axle boxes arranged so that the weight of the engine will rest on springs?*

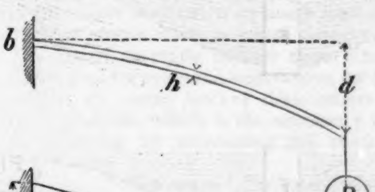


Fig. 287.

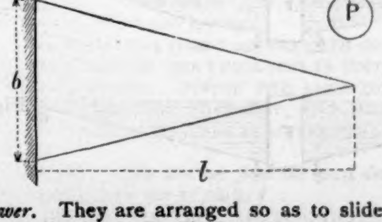


Fig. 288.

Answer. They are arranged so as to slide up and down in the jaws. Springs, *B, B'*, fig. 286, are then placed over the axle-boxes and above the frames. These springs rest on ∩-shaped saddles, *G, G'*, which bear on the top of the axle-boxes. The frames are suspended to the ends of the springs by rods or bars, *g, g', g, g'*, called *spring-hangers*. As the boiler and most of the other parts of the engine are fastened to the frames, their weight is suspended on the ends of the springs, which, being flexible, yield to the weight which they bear.

QUESTION 459. *How are the frames protected from the wear of the axle-boxes which results from their sliding up and down in the jaws?*

Answer. The insides of the legs, *a, a', b, b'*, are protected with *shoes* or *wedges*, *h, h'*, which are held stationary, and the boxes slide against the faces of the shoes, thus wearing the shoe or wedge, but not the frame.

QUESTION 460. *Why is one or both of the shoes made wedge-shaped?*

Answer. They are made in that way so that when they become worn, by moving one or both of them up in the jaws, the space between them is narrowed and the lost motion is taken up. They are moved by the screws, *i, i*. If the boxes should become loose from wear, it would cause the engine to thump at each revolution of the wheels or stroke of the piston.

QUESTION 461. *How are the springs for the driving-wheels made?*

Answer. They are made of steel plates, which are placed one on top of the other. These plates are of different lengths, as shown at *B, B*, in fig. 286, and are from 3 to 4 in. wide and $\frac{5}{16}$ to $\frac{7}{16}$ thick. The length of the springs measured from the center of one hanger to the center of the other is usually about 3 ft.

QUESTION 462. *What determines the amount which a spring will bend under a given load?*

Answer. The number of plates, their thickness, length and breadth, and of course the material of which they are made. This can be explained if we suppose we have a spring-plate of a uniform thickness, *h*, and a triangular form, of which fig. 287 is a side view and 288 a plan, and that it is clamped fast at its base, *b*. It is a well-known mechanical law that any material of this form and under these conditions will have a uniform strength through its whole length to support any load, *P*, suspended at its end, and also that it will bend or deflect in the form of an arc of a circle.

QUESTION 463. *How are locomotive springs usually made?*

Answer. In locomotives the arrangement of springs is always such that they are either supported in the middle and moved at the two ends, or such that they are supported at the two ends and loaded in the middle; for our consideration it is indifferent which of the two kinds of springs is taken for the present illustration. That shown in plan and elevation in figs. 289 and 290, which is formed of a wide plate placed diagonally, and which in reality consists of two such triangular pieces as were represented in fig. 288 united at their bases *m m*, fig. 290, and loaded at two opposite corners, *e* and *f*, would answer the requirements mentioned if the great breadth, *m m*, were not an obstacle. This breadth is obviated by cutting the spring into several strips, *a a, b b, c c, d d, ... i*, fig. 290, of equal width, and placing these not side by side, but one over the other, as shown in figs. 291 and 292.

In order that the separate strips and layers of the spring so made may not slip out of place, the strips *a a, b b*, etc., are made in one piece, and all the plates are enclosed with a strap, *F*, figs. 293–295. The plates, instead of being cut from a piece like that represented in fig. 290, are, however, made out of steel of the proper width, and the ends, instead of being cut off pointed as represented, are sometimes drawn out thinner on the ends, like the point of a chisel, or oftener still cut off straight, as shown in fig. 295.

The band, *F*, which is put around the middle, is put on hot, and becomes tight by contracting as it cools. The center of the spring has a hole drilled through it with a pin, *s*, fig. 294 (which shows a cross section of a spring), to prevent the plates from sliding endwise. The plates at each end usually have a depression, *a*, fig. 296 (which is a cross section of a plate on a larger scale than the preceding figure), made in them on one side, and a corresponding elevation, *b*, on the other. The elevation on one plate fits into the depression on the other, and thus prevents the plates from slipping sideways.

Fig. 289.

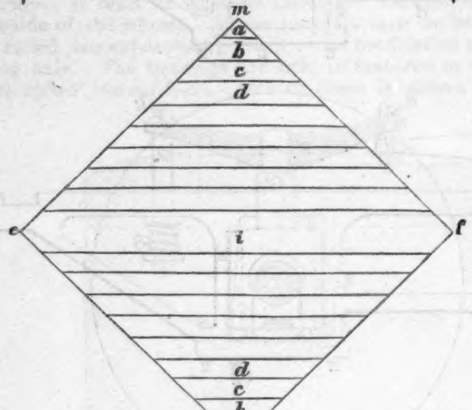


Fig. 290.

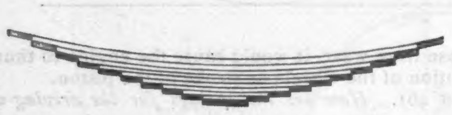


Fig. 291.

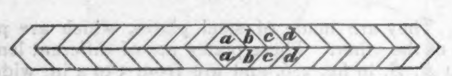


Fig. 292.

QUESTION 464. *How should springs be curved?*

Answer. Springs should be curved so that when they bear the greatest load which they must carry they will be straight. If they are curved too much they are subjected not only to a strain which bends the plates, but to one which has a tendency to compress them endwise. Thus if a spring like that represented in fig. 297 is bent into a half-circle, it is obvious that the strain at the ends has no tendency at all to bend the plates, but only to compress them endwise. Near the middle the strain

Fig. 293. Fig. 294.

Fig. 295.

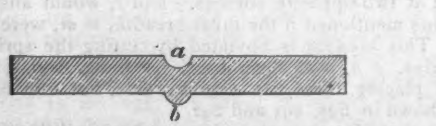


Fig. 296.

will, of course, bend the spring. In the one direction the spring is flexible and elastic, and in the other it is not; and as the strain of compression depends on the amount of curvature, the greater the latter is, the less flexibility and elasticity the spring will have.

Springs are often given a double curve, as shown in fig. 298. This is not to be recommended, because when a spring bends the plates must slide on each other. If they have but a single curve, they will do so and remain in contact through their whole length, but if they have two curves they will separate and therefore "gape," as it is called.

QUESTION 465. *What is the shape of the band on the spring?*

Answer. The bands are usually made of the form shown in fig. 293, but recently they have been made * of the form shown in fig. 299—that is, narrower on the under side than on top. This allows the lower and shorter plates to bend more than they could if held by a wider band, and gives them greater elasticity.

QUESTION 466. *What is meant by the elasticity of a spring?*

Answer. It is the amount which a spring will deflect or bend under a given load without having its form permanently changed. If the bending is so great that the spring does not recover its original form when the load is removed, then the strain to which it is subjected is said to exceed *the limits of elasticity*, and if repeated often it will ultimately break the spring.

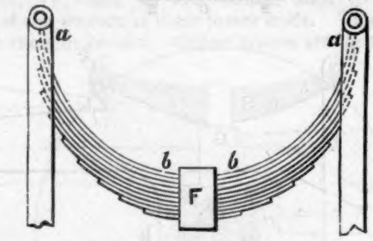


Fig. 297.

QUESTION 467. *What is meant by the elastic strength and the ultimate strength of a spring?*

Answer. The *elastic strength* is the strain it will bear without being strained beyond the limits of elasticity, and the *ultimate strength* is the strain which will break it.

QUESTION 468. *What determines the strength of a spring?*

Answer. It depends, of course (1), upon the material of which the spring is made; (2) its strength increases in propor-

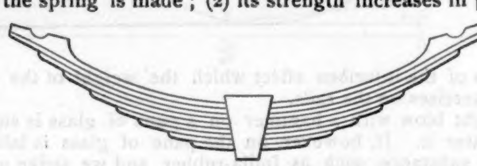


Fig. 299.

tion to the number of plates, and (3) to their width, and (4) in proportion to the square of their thickness, and (5) as the length diminishes.

Thus, if we wanted to double the strength of a spring like that shown in figs. 287 and 288, it could be done in either of

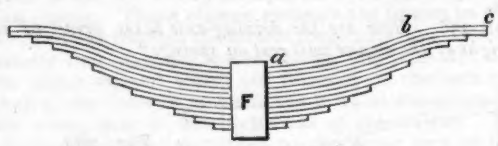


Fig. 298.

Fig. 301.

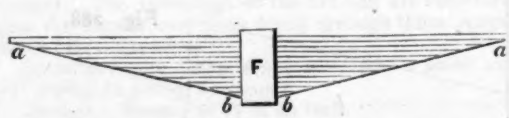


Fig. 300.

the following ways: (1) by making it of material twice as strong; (2) by putting another plate just like it on top; (3) by doubling the width of the base *b*, which would make the strength of the whole plate twice what it was before; (4) by making the whole plate about four-tenths thicker, which would increase its strength, as already stated, in proportion to the square of the thickness as $1.4 \times 1.4 = 2$ nearly; (5) by reducing the length to one-half what it is in fig. 287.

QUESTION 469. *What determines the elasticity of a spring?*

Answer. (1) The material of which it is made; with the same material the elasticity increases (2) as the number and

* By the A French Spring Company of Pittsburgh.

(3) as the width of the plates diminishes, and (4) with the cube of the length, and (5) decreases with the cube of the thickness of plate.

Thus, supposing the plate in figs. 287 and 288 to be $\frac{5}{8}$ in. thick and the deflection *d* $2\frac{1}{2}$ in.; the latter would be only half as much, or $1\frac{1}{4}$ in. (1), if it were made of material twice as stiff, or (2) with two such plates, or (3) with one twice as wide at the base. If (4) the length were doubled, the deflection would be equal to $2 \times 2 \times 2 = 8$ times what it was before, or in proportion to the cube of the length. If (5) the thickness were doubled the deflection would be *reduced* in the same proportion, and would be only one-eighth of $2\frac{1}{2}$ in., or $\frac{5}{16}$ in.

QUESTION 470. *What should be the proportion of the plates of a spring in relation to each other?*

Answer. The lower plates should diminish regularly in their lengths. The reason for this will be apparent from the fact which has already been stated, that if a triangular plate of uniform thickness is clamped fast at its base, it will, if loaded at the end, be of uniform strength throughout its whole length. It is immaterial what the length of the base of such a triangle is; if the two sides are of equal length and the thickness of the plate is uniform, not only its strength, but the amount of deflection or bending from any load will be equal all through its length. If, therefore, we make a spring by cutting a plate formed of two such triangular pieces united at their bases into strips, as has already been explained, evidently the spring made of them will have a uniform strength throughout its whole length. As the strips thus made diminish in length regularly, it is evident that if the spring plates are made of steel rolled of the requisite width, their length should be the same as that of those cut from the plate referred to above. When this is the case, the lower outline, *a b b a*, fig. 300, of the spring will, when the spring is not bent, be straight lines. Sometimes the lower outline of springs is made curved, as shown in fig. 301. This gives too much stiffness between the middle *b b* and the ends *a a*. In drawing springs, therefore, it is best to lay them out with the plates straight, as shown in fig. 300, and after determining the thickness, drawing a straight line from a point near the strap to the end of the longest plate will give the best form of the spring and the length of each of the plates. It is necessary, however, to put a sufficient number of long plates in each spring to give it the required strength next to the attachment of the hanger. Sometimes one or more of these long plates are made thicker than the rest. The evil of this method of construction will be apparent if it is remembered that the greatest permissible deflection up to the breaking of the spring decreases with the *cube* of the thickness of the plate and its strength increases with the *square* of the thickness. Now if we have a spring with say ten plates $\frac{3}{8}$ in. thick and one on top $\frac{3}{4}$ in. thick, the thick plate will have a strength *four* times that of the thin plates, but its elasticity will be only one-eighth that of the thin plates, and therefore it will require eight times as much load to bend it any given distance as is needed to bend the thinner plates the same distance. But its strength is only four times that of the thin plates, so that for any given amount of elasticity the thick plate must bear twice as much load as it has strength to carry. This shows what a great mistake is committed if some of the plates are made thicker than others, a conclusion which is supported by practical experience, as it is found that if the top plates are made thicker than others, the thick ones break most frequently, which is the necessary result of the supposed strengthening by increasing the thickness of the top plates.

QUESTION 471. **How can we find by calculation the elasticity or deflection of a given s'eel spring?*

Answer. BY MULTIPLYING THE BREADTH OF THE PLATES IN INCHES BY THE CUBE OF THE THICKNESS IN SIXTEENTHS, AND BY THE NUMBER OF PLATES: DIVIDE THE CUBE OF THE SPAN† IN INCHES BY THE PRODUCT SO FOUND, AND MULTIPLY BY 1.66. THE RESULT IS THE ELASTICITY IN SIXTEENTHS OF AN INCH PER TON OF LOAD.

QUESTION 472. *How can we find the span due to a given elasticity and number and size of plates?*

Answer. BY MULTIPLYING THE ELASTICITY IN SIXTEENTHS PER TON BY THE BREADTH OF PLATE IN INCHES, AND BY THE CUBE OF THE THICKNESS IN SIXTEENTHS, AND BY THE NUMBER OF PLATES: DIVIDE BY 1.66, AND FIND THE CUBE ROOT OF THE QUOTIENT. THE RESULT IS THE SPAN IN INCHES.

QUESTION 473. *How can we find the number of plates due to a given elasticity, span, and size of plate?*

Answer. BY MULTIPLYING THE CUBE OF THE SPAN IN INCHES BY 1.66; THEN MULTIPLYING THE ELASTICITY IN SIXTEENTHS BY THE BREADTH OF PLATE IN INCHES, AND BY THE CUBE OF THE THICKNESS IN SIXTEENTHS: DIVIDE THE FORMER PRODUCT BY THE LATTER. THE QUOTIENT IS THE NUMBER OF PLATES.

QUESTION 474. *How can we find the working strength—that is, the greatest weight it should bear in practice, of a given steel-plate spring?*

Answer. BY MULTIPLYING THE BREADTH OF PLATES IN INCHES BY THE SQUARE OF THE THICKNESS IN SIXTEENTHS, AND BY THE NUMBER OF PLATES; MULTIPLY, ALSO, THE WORKING SPAN IN INCHES BY 11.3: DIVIDE THE FORMER PRODUCT BY THE LATTER. THE RESULT IS THE WORKING STRENGTH IN TONS (OF 2,240 POUNDS) BURDEN.

QUESTION 475. *How can we find the span due to a given strength, and number and size of plate?*

Answer. BY MULTIPLYING THE BREADTH OF PLATE IN INCHES BY THE SQUARE OF THE THICKNESS IN SIXTEENTHS, AND BY THE NUMBER OF PLATES; MULTIPLY, ALSO, THE STRENGTH IN TONS BY 11.3: DIVIDE THE FORMER PRODUCT BY THE LATTER. THE RESULT IS THE WORKING SPAN IN INCHES.

QUESTION 476. *How can we find the number of plates due to a given strength, span and size of plates?*

Answer. BY MULTIPLYING THE STRENGTH IN TONS BY THE SPAN IN INCHES, AND BY 11.3; MULTIPLY, ALSO, THE BREADTH OF PLATE IN INCHES BY THE SQUARE OF THE THICKNESS IN SIXTEENTHS: DIVIDE THE FORMER PRODUCT BY THE LATTER. THE RESULT IS THE NUMBER OF PLATES.

QUESTION 477. *How can we find the required amount of curvature or set of the spring before it is loaded?*

Answer. BY MULTIPLYING THE ELASTICITY, PER TON, IN INCHES, BY THE WORKING STRENGTH IN TONS; ADD THE PRODUCT TO THE DESIRED WORKING COMPASS. THE SUM IS THE WHOLE ORIGINAL SET, TO WHICH AN ALLOWANCE OF $\frac{1}{2}$ TO $\frac{5}{8}$ IN. SHOULD BE ADDED TO THE PERMANENT SETTING OF THE SPRING.

QUESTION 478. *How are the spring-hangers attached to the ends of the springs?*

Answer. A great variety of methods have been used. The most common ones are those shown in fig. 286, in which the hangers consist of single bars which pass through openings or *eyes* in the ends of the springs, and have keys, *k k*, which bear on top of the springs. Sometimes the hangers are made to embrace the ends of the springs, as shown at *a a*, figs. 293 and 295. The springs have projections forged on their ends to receive the keys in the upper end of the hangers, which are made to fit the grooves formed between the projections.

QUESTION 479. *How are the lower ends of the hangers held?*

Answer. The front hanger, *g*, fig. 286, of the front spring, and the back hanger, *g*, of the back spring are attached to the frame as shown. Sometimes a coiled or rubber spring, *S*, is interposed between the hanger and the frame to give more elasticity. The hangers *g' g'* are attached to the ends of a lever, *A A*.

(TO BE CONTINUED.)

* The following rules for calculating the proportion and strength of steel springs are from Clark's Railway Machinery.

† The span is the distance between the centers of the spring-hangers when the spring is loaded.

Manufactures.

Cars.

THE United States Rolling Stock Company now employs 600 hands at its shops in Anniston, Ala., turning out about 12 freight cars a day. A new wood-working shop 105 by 1,500 ft. is nearly completed.

THE Roanoke Machine Works at Roanoke, Va., has closed a contract for building 1,000 box cars and 2,000 dump cars for the Central Railroad Company of Georgia. The cars are to be of 60,000 lbs. capacity.

THE Harlan & Hollingsworth Company in Wilmington, Del., has just completed a car specially designed and arranged for carrying valuable race-horses. It is the property of Mr. John A. Morris, of Westchester, N. Y.

VESTIBULES are being applied to the cars on through fast trains of the Baltimore & Ohio Railroad as rapidly as possible at the Mount Clare shops. The first of these vestibule trains was put into regular service between Baltimore and Chicago, August 20.

THE Kansas City Car & Wheel Company is running its shops on orders for 100 coal cars for the Kansas City, Fort Scott & Memphis Railroad, 160 ore cars for the Union Pacific, and a number of smaller orders.

THE Barney & Smith Manufacturing Company in Dayton, O., has recently completed four passenger cars for the New York, Susquehanna & Western and 300 coal cars for the Kansas City, Fort Scott & Memphis.

J. G. BRILL & COMPANY, in Philadelphia, have received an order for 125 cars for the new Mexican Interoceanic Road.

THE Norfolk Southern Railroad Company has added to its rolling stock 50 iron platform cars of 40,000 lbs. capacity.

THE Hainsworth Steel Company has been organized in Pittsburgh for the purpose of manufacturing rolled cast-steel car wheels, under the process recently patented by Mr. William Hainsworth, Superintendent of the Pittsburgh Steel Casting Company.

THE Pennsylvania Company has recently equipped at its Fort Wayne shops a train of stock cars, for the purpose of giving engineers and freight trainmen instruction in the use of air-brakes. This train will be run over the company's lines, stopping at all division points long enough to give proper instruction. The engine is equipped with an ordinary three-way cock, engineer's brake-valve, and engineer's brake-valve with equalizing port, the valves being connected with the train-pipe so that any one of them can be used in applying the brakes; in this way engineers become familiar with the use of the three different valves.

The cars, 25 in number, are equipped with Westinghouse freight brakes with quick-acting valve. While in use as a school this train will be under the charge of W. W. Todd, General Car Inspector for the company.

A New Screw-Power Testing Machine.

THE accompanying illustration represents a new screw power testing machine for ascertaining the strength of metals and other materials under tensile, transverse, or compression strains, combining the elements of accuracy, speed, and facility of handling. The machine is constructed of the best materials, and the levers adjusted to the standard weights of the United States Government. There are three different speeds for testing a specimen and also for driving in the opposite direction. This allows of all the possible requirements of a wide range of material. There are no loose weights, and a single traveling poise, operated by a light hand-wheel, registers the strain accurately by means of a vernier. The power is applied by a crank with loose sleeve handle.

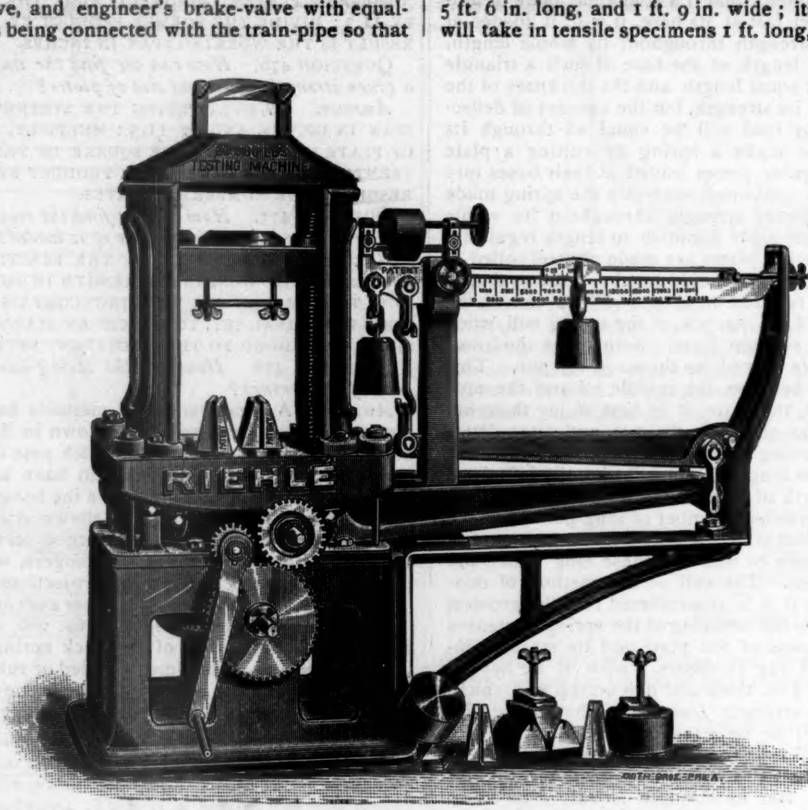
Tools are furnished with the machine for making the various tests, and there are stops and holders for the grips, etc., as well as bolts and cushions for checking the recoil and keeping the platform in place. The levers are arranged in tandem style, so that the machine will take up as little room as possible and allow a clear deck for transverse tests.

As the size of this compact machine is not very great, it is advisable to mount it on a solid wooden platform, from 16 to 18 in. high, so as to bring the crank and beam to a convenient working height, and made to suit the size of the machine base.

The crank can be slipped on any of the three key-end shafts, and thus secure three changes of speed in testing. On stopping the crank the machine will maintain the pressure on specimen as long as desired.

This style of machine is being built in the following sizes: 10,000 lbs., 20,000 lbs., 30,000 lbs., 60,000 lbs., 100,000 lbs., and 200,000 lbs. capacity, and can be built of increased capacity if desired. The 20,000-lbs. machine, which is the size shown in the engraving, is, in extreme dimensions, 4 ft. 6 in. high, 5 ft. 6 in. long, and 1 ft. 9 in. wide; its weight is 1,400 lbs. It will take in tensile specimens 1 ft. long, with 30 per cent. elongation, transverse specimens up to 15 in. long, and compression up to 10 in. long. The motion of the pulling head is 17 in.

These machines are made by Riehle Brothers, of No. 413 Market Street, Philadelphia.



IMPROVED SCREW-POWER TESTING MACHINE.

Locomotives.

THE Canadian Pacific shops in Montreal are building a number of 10-wheeled passenger engines with 18 by 22-in. cylinders for use on the mountain section of the road.

H. K. PORTER & COMPANY, Pittsburgh, recently built a new passenger engine for the Castle Shannon narrow-gauge road.

STRUTHERS, WELLS & COMPANY have begun the manufacture of locomotives for logging railroads at their shops in Warren, Pa. These locomotives will be of a design patented by W. L. Sykes of that place.

THE Pittsburgh Locomotive Works are building several very heavy engines with 19 by 28-in. cylinders and 59-in. drivers for the Calumet Terminal Railroad Company of Chicago.

THE Rhode Island Locomotive Works recently delivered four 10-wheeled engines with 18 by 24-in. cylinders to the Southern Pacific Company. They are intended for the Oakland local passenger service of the Central Pacific Road.

THE Cooke Locomotive Works are making preparations to build new shops in Paterson, being unable to make proper arrangements for the extension of their business on the present site. The new shops will be much more conveniently placed

than the old ones, as the company will have plenty of ground, and the shops can be connected with both the Erie and the Delaware, Lackawanna & Western roads by sidings or spur tracks, thus avoiding the slow and expensive hauling which is necessary in their present situation.

Blast Furnaces of the United States.

THE *Iron Age* gives the following statement of the condition of the blast furnaces on September 1:

Fuel.	In Blast.		Out of Blast.	
	Furnaces.	Weekly capacity.	Furnaces.	Weekly capacity.
Anthracite coal	92	33,541	94	21,674
Bituminous coal and coke	133	81,082	74	33,895
Charcoal	67	11,243	109	10,004
Total	292	125,866	277	65,573

The total weekly capacity of the furnaces in blast was 7,101 tons less than on September 1, 1887. but there was an increase of 6,577 tons in capacity during the month of August.

Manufacturing Notes.

THE McLeod Railway Signal Company, of Boston, has purchased property and is building shops at Canton, O., for the manufacture of its signals.

THE Martin Anti-Fire Car Heating Company, of Dunkirk, N. Y., recently placed an order for a large number of reducing valves with the Mason Regulator Company, of Boston.

THE Aluminium Brass and Bronze Company was recently organized at Waterbury, Conn., for the manufacture of bronze from aluminium and other alloys. Mr. Charles S. Morse will be the General Superintendent. The supply of aluminium will be supplied from Cowles's furnaces at Lockport.

THE Lookout Rolling Mill at Chattanooga, Tenn., is now running iron bars 100 ft. long, and is making arrangements to turn out bars up to 130 ft. in length.

THE Bethlehem Iron Company, Bethlehem, Pa., recently filled an order for steel rails weighing 90 lbs. per yard for the Philadelphia & Reading Company; they are to be used in that company's passenger yard in Philadelphia.

THE Atlanta Bridge & Axle Company in Atlanta, Ga., has taken the contract to build a new four-span iron bridge over the Muscogee River for the Central Railroad of Georgia.

D. W. C. CARROLL & Co., of Pittsburgh, have closed a contract for the erection of two iron viaducts for the city of Denver, Col., to cross the railroads, which all center in one part of that city. One viaduct is to be 376 ft. long and 32 ft. high, and the other 785 ft. long and 32 ft. high. The viaducts are to be made of structural iron, including the approaches. They will be of sufficient width to allow of a driveway and two footpaths.

THE Penn Bridge Works at Beaver Falls, Pa., have a number of contracts for small bridges, and are making the iron roof for the Government buildings in Rochester, N. Y.

THE Keystone Bridge Company has taken the contract for a large bridge or viaduct at St. Paul, Minn. It will extend from the end of the bridge over the Mississippi River across the flats to the top of the bluff, and will have about 20 spans, four of 250 ft. each, one of 170 ft., and the remainder varying from 90 to 40 ft. The bridge will be carried on iron piers, two of which will be 150 ft. high. The same company has taken the contract for building the new Polk Street Viaduct over the Chicago & Northwestern tracks in Chicago.

Electric Street Cars.

IT is announced that the Westinghouse Electric Company, Pittsburgh, is about to undertake the manufacture of electric motors for cars. The company has been engaged for some time in experimenting with tests of the new Tesla motor, and the results, it is understood, have been so favorable that its manufacture on a large scale will be undertaken.

THE Bentley-Knight Electric Railroad Company is building a conduit line for the West End Street Railroad Company of Boston. This line is to run from the Providence Station along Boylston Street around and pass through Trinity Square and the new Beacon Street extension to Brookline.

THE Thomson-Houston Electric Company has just arranged for the completion of a plant for street railroads in Seattle, Wash. Terr.; the road is four and a half miles long. The same company has also contracted to build an electric line in Bangor, Me. This line is two miles long and will use the overhead conductor, operating 10 cars. The company is also arranging to equip with its motor street railroads in Des Moines, Ia., Syracuse, N. Y., and Scranton, Pa., and is negotiating for the equipment of street lines at Lynn, Mass., besides several other lines.

Deoxidized Copper.

THE advantages to be obtained by the use of copper as nearly chemically pure as possible are generally admitted, whether the metal be used as copper, or in the form of brass, bronze, or the many other alloys into which it enters. The Deoxidized Metal Company, of Bridgeport, Conn., claims that the desired result is secured by the process which is used in its works. The castings of brass, bronze, etc., made under this process are most excellent, while the sheet copper and brass, and the wire made, when submitted to careful tests, show an unusually high degree of strength, copper wire having been tested up to 70,000 lbs. per square inch, tensile strength. The deoxided metal also possesses the property of great resistance to acids, so that it can be used for many purposes where ordinary metal is soon destroyed by the chemical action. Journal-bearings made from this metal have also been tested with very favorable results, while for bells it is claimed that the tone and quality is much superior to ordinary brass.

Southern Iron Production.

ALABAMA heads the list of Southern States in the production of pig iron, Tennessee and Virginia ranking next. The following table taken from the Baltimore *Manufacturers' Record* shows the relative position of some of the leading iron-producing States of the South, in tons:

	1880.	1887.	*Increase.*
Alabama	77,190	292,762	215,572
Tennessee	70,873	250,344	179,471
Virginia	29,934	175,715	145,781
Georgia	70,000	82,000	12,000
West Virginia	27,947	40,947	13,000

The chief increase has been in Alabama, Tennessee, and Virginia, comparatively small changes having taken place in West Virginia and Georgia.

A Model Steam-Heating Plant.

THE extensive works of the Russell & Erwin Manufacturing Company at New Britain, Conn., are heated by a very complete and compact plant, which was designed by and built under the supervision of Mr. T. S. Bishop, the Engineer of the Company.

This steam plant is entirely distinct from the other part of the works. The boilers are supplied with coal directly from iron cars which are run in on a track from the coal-yard, thus doing away with the necessity of a coal pile in the boiler-room, and insuring perfectly clean floors; these cars hold about one ton each. The water is taken from a reservoir to the engine, and thence to the boiler feed-pumps; from these pumps it passes through a feed-water heater, which consists of about 5,000 linear feet of 1-in. brass pipe placed in the smoke-flue to the main chimney. After leaving this heater the water passes through a settling drum, which allows the mud and other deposits to be drawn off at convenience. The discharge from the traps on the heating system in a large part of the works is also returned to the feed-pumps.

Where possible the steam mains or pipes are laid in trenches, which are covered with flag-stone to allow easy access for inspection and repairs. Lamp-black insulation is used for all pipes so laid. For heating the factory buildings an overhead system of piping is used.

The expansion joints in the mains are the variators devised by Charles E. Emery, of New York, for the New York Steam-Heating Company, and are placed from 90 to 100 ft. apart.

There are 10 boilers now in use, all of the horizontal tubular type, 6 ft. diameter and 17 ft. long, each boiler having 140 tubes 3 in. diameter and 16 ft. long. Two more boilers are to be added this year. These boilers were all made by Kendall & Roberts, of Cambridgeport, Mass.

The chimney to the boiler-room is 175 ft. high above ground, and 7 ft. internal diameter. The base of the stone-work at the surface of the ground is 21 ft. in diameter. This base is 6 ft. high, of rock-faced Portland sandstone. Above this the brick-work is circular, 18 ft. diameter for 10 ft., and is then surmounted by a cut stone water-table; upon this water-table the shaft rises in horizontal sections formed by two squares, making the section of the chimney an eight-pointed star; regular square brick can thus be used throughout. The top flares out considerably, and is surmounted by an iron cap 21 ft. diameter, and weighing about four tons. The chimney shaft has a batter throughout of about ½ in. to the foot. The central core is of fire-brick, and there is a ventilating space of 4½ in. clear between this and the main walls of the chimney.

Provision is made against fire in the works by an independent fire apparatus consisting of two steam-pumps, with steam cylinders 20 in. diameter and 24-in. stroke, made by the Knowles Steam-Pump Works at Warren, Mass. These pumps are supplied with steam from two Herreshoff coil boilers. From these pumps 8-in. main pipes are laid through the streets around and between the various buildings, with numerous hydrants to which hose can be attached from two carriages always kept in readiness. There is a fire company, composed of the employés of the works, fully organized and equipped. This fire plant was designed by the Knowles Steam-Pump Company.

In order to provide against contingencies a special steam main is now being put down from the power boilers to the fire-pumps; when this is completed steam can be taken and the pumps started at any time, should an emergency arise, without delay, and without the necessity of keeping or starting fire in the special boilers.

Proceedings of Societies.

American Society of Civil Engineers.

THE first meeting of the season was held at the Society's house in New York, September 5, Vice-President Croes in the chair. A paper was read by Edward E. Magovern on the Theory of Aqua-Ammonia Engines, giving results of tests made on an engine of this type employed in running an Edison incandescent lighting plant.

The tellers announced the following elections:

Members: William James Baldwin, New York City; Elbridge Leonard Brown, Brockton, Mass.; Edward Bertie Codwise, Kingston, N. Y.; Walter Whaley Curtis, Fort Madison, Ia.; Arthur Powis Herbert, City of Mexico; Edward Maguire, Willett's Point, N. Y.; Arthur John Mason, Kansas City, Mo.; Charles Henry Nash, Bloomfield, N. J.; William Scherzer, Chicago, Ill.; William Humphrey Wightman, Palouse, Wash. Terr.

Associate—William Gibson, Jr., New York City.

Juniors—St. John Clarke, High Bridge, N. Y.; Walter H. Gahagen, La Salle, Ill.; Mason Delano Pratt, Johnstown, Pa.

AT the regular meeting of September 19 several written discussions of Colonel W. P. Craighill's paper on Improvement of Several of the Rivers of the Atlantic Coast were presented, and the paper was further discussed by members present.

New England Water-Works Association.

THE regular quarterly meeting, held in Cambridge, Mass., September 12, was the yearly field day. After a short business session a visit was paid to Harvard College, and the rest of the day was spent in visiting the water-works and the Fresh Pond and Stony Brook reservoirs. Lunch was served at the pumping station, and the members were entertained at dinner in the evening by the City Government.

Civil Engineers' Association of Connecticut.

THE summer meeeting was held in New London, August 22. The principal feature of the meeting was a paper presented by J. A. Monroe describing the engineering features of the new Thames River Bridge. After the reading of the paper the members of the Association inspected the work in progress on the bridge, and the meeting concluded with a sail around the harbor and a dinner.

Engineers' Club of Cincinnati.

AT the regular meeting, August 1, five active members were added. The report of the special committee, to which was referred communications from the Engineers' Club of Kansas City and the Western Society of Engineers in relation to State inspection of bridges, was submitted and approved by the Club. The report advocates the coöperation of engineering societies in favor of State inspection of highway and railroad bridges, and recommended the appointment of a standing committee to represent the Club. The Club, however, did not consider it desirable to establish any scale of minimum prices for preparing plans and specifications for bridges.

Colonel Anderson presented a paper on the Best Method for Establishing Points of Reference in City Surveying, in which he advocated the adoption of a method similar to that now in use in Philadelphia.

Western Society of Engineers.

THE 250th meeting was held in Chicago, September 5, Vice-President John W. Weston in the chair. Mr. Henry S. Maddock was elected a member.

After the reports of the Secretary and Treasurer, Mr. Weston, from the Committee upon Memoirs of Messrs. Baker and Latimer, submitted a report which was ordered printed.

The Secretary was instructed to forward paper with discussions upon Classification of Material in Railway Construction, for publication.

Mr. Rossiter called attention to the desirability of a translucent profile paper, suitable for blue printing, and thought that great improvement could be made in the standard papers used by engineers. After some discussion Messrs. Rossiter, Williams, and Parkhurst were appointed a committee to report on the question.

A paper by Mr. George Y. Wisner, upon Levels of the Lakes as Affected by the Proposed Lake Michigan and Mississippi Water-way, was read by the Secretary. After a short discussion the paper was laid over until the next meeting.

The report of Committee on Employment was made the special order for the next meeting.

Minneapolis Society of Civil Engineers.

AT the September meeting Mr. Cappelen read a paper describing the construction of the Northern Pacific bridge in South Minneapolis, in which he gave especial attention to the river bed, and incidentally spoke of the foundation of all the bridges across the river there.

Engineers' Club of Kansas City.

A REGULAR meeting was held in Kansas City, September 3. Walton Clark and Edmund Saxton were elected members.

A description of a new cable railroad grip was given by Mr. Harris.

This was followed by a note on Flood Waves of the Missouri River, by J. T. Wallace, and a letter referring to the Shrinkage in Earthwork from B. W. De Courcy, both of which were discussed by members present.

A number of additions to the library were announced.

New England Railroad Club.

THE first meeting for the season was held at the Quincy House, Boston, on the evening of September 19. According to the custom of this Club, this meeting was the annual dinner, and it was much enjoyed. About 125 members and guests were present, and after the dinner had been disposed of a number of speeches were made. An active season is promised for the Club.

Western Railroad Club.

THE first meeting of the season was held in Chicago, September 19. The following officers were chosen: President, G. W.

Rhodes; Vice-President, John Hickey; Treasurer, W. B. Snow; Secretary, W. B. Crossman.

Mr. Hickey read a paper on Circulation of Water in Locomotive Boilers, and Mr. W. Forsyth one on Material for Car Construction. Both papers were discussed.

It was resolved to hold the meetings on the Tuesday before the last Thursday in each month. Committees were appointed to arrange for reports of meetings and to secure permanent quarters.

Master Car and Locomotive Painters' Association.

THE annual convention was held in Cleveland, O., September 13 and 14, with a full attendance. A number of papers of much interest were read and discussed.

The following officers were elected for the ensuing year: President, Samuel Brown, Old Colony Railroad, Boston. Vice-Presidents, W. T. Hogan, Atchison, Topeka & Santa Fé, Topeka, Kan.; William Lewis, Grand Trunk, London, Ont. Secretary and Treasurer, Robert McKeon, New York, Pennsylvania & Ohio, Kent, O.

National Electric Light Association.

THE eighth semi-annual meeting of the National Electric Light Association begun at the Hotel Brunswick, New York City, August 29, the President of the Association, Mr. S. A. Duncan, of Pittsburgh, in the chair. After an address by the President, calling attention to statistics as to the amount of electric light apparatus in use in this country, Mayor Hewitt was introduced and delivered an address of welcome.

Mr. W. H. Harding, the Secretary and Treasurer, then presented his report, showing a net membership of 189, being a notable increase, and funds in hand of about $1,000.

The Committee on Insulation and Installation presented their report, enclosing schedule of data to be asked for from members. After some discussion the report was accepted and the committee continued.

A paper on Petroleum Fuel by Mr. S. S. Leonard, of Minneapolis, was read, calling attention to its advantages over other fuels. After a very interesting discussion the Convention adjourned until Thursday morning at 10 o'clock.

SECOND DAY.

Communications relative to the Paris Exposition of 1889 and the Centennial Exhibition at Cincinnati were received.

A committee was appointed to consider the recommendations embodied in the President's address and to report thereon.

Mr. S. S. Wheeler then read a paper on Overhead and Underground Wires in New York, followed by a short discussion on the cost of conduits.

In the afternoon the first paper was by Mr. E. G. Acheson on Disruptive Discharges and Their Relations to Underground Cables.

Mr. Alexander Crawford Chenoweth read the next paper, A Description of an Underground Conduit. On motion it was voted to appoint a committee to examine and report upon the underground wire question.

A communication from Mr. C. J. Field was read, inviting the members to inspect the lighting arrangements of the new Broadway Theater, also one from the Shultz Belting Company to inspect a belt at the East River Electric Company's station.

The revised constitution was then adopted.

THIRD DAY.

Mr. Frank Ridlon read the report of the Committee on Insurance Exchange, giving details of the methods pursued by the Boston Electric Exchange, and of the reduced rates granted by the New England Electric Exchange to licensees of the former.

Dr. P. H. Van der Weyde's paper was then read by Mr. Stewart on the Comparative Danger of Alternating *vs.* Direct Currents. The paper drew forth a brief discussion.

A paper on Some Methods of Electrical Measurements was read by Dr. G. A. Liebig, Jr., and then Mr. E. R. Weeks read a paper on Electrical Education, which was discussed.

Mr. H. L. Lufkin read a paper on a Basis from which to Calculate Charges for Electric Motor Service, which was discussed at some length by some of the members.

On Wednesday evening a large party was taken by the *Electrical Review* to Staten Island, to see "Nero."

On Friday evening a couple of hundred of the delegates left by the steamer *Catskill* for Providence, to take part in a clambake given on Saturday by the American Electrical Works and to proceed thence to Newport. The members then dispersed to their respective homes.

Roadmasters' Association of America.

THE sixth annual convention began in Washington, September 11, President J. W. Craig in the chair. The morning session was devoted to the election of members, reports of the officers, and other routine business. The Secretary reported 348 members, and 60 were added at this session. There were present at the meeting about 90 members.

The first business of the afternoon session was the report of the Committee on Standard Rail-Joints. Messrs. P. Nolan, A. B. Adams, and T. Hickey of the Committee offered the following:

"MAJORITY REPORT.—The undersigned, a majority of the Committee on Standard Track-Joints, beg leave to submit the following report: That the best device now known to them for a standard joint is the angle-bar. That this angle-bar should be from 42 to 44 in. in length, with slots for spikes 2 and 6 in. from the ends, with six bolt holes, spaced from 5 to 7 in. apart, resting on three ties, 9×7 in. and 8 in. apart, weight 50 lbs. per pair for a 60-lb. rail, and increased proportionately for increased weight of rail, shaped to conform to the head and flange of the rail, allowing about $\frac{3}{16}$ in. space between the splice and the web of the rail to permit of tightening. The cross-section of joint shown by fig. 6, page 28 of annual report for 1887, meets our views as to shape and fit. The bolt holes in both plates should be oblong in form, and round or button-head bolts be used. For rails weighing from 60 to 70 lbs. per yard a splice bolt $\frac{3}{4}$ in. in diameter, with a square nut of the proper size, should be used when practicable; and for rails weighing over 70 lbs. per yard a bolt $\frac{7}{8}$ in. in diameter of the same form should be used, and a metal washer or spring should be used between the nut and plate. As far as we now know we are in favor of giving the angle-bar, made heavy in the center and tapered toward the ends, a more extended trial before deciding on its merits over one of a uniform thickness throughout. That we decidedly prefer a supported joint to what is generally known as a suspended joint."

Messrs. R. Caffrey and H. D. Hanover of the Committee presented the following:

"MINORITY REPORT.—The undersigned, a minority of the Committee on Standard Track-Joints, submit the following report: That we still adhere to all the recommendations for a standard joint named in the report submitted at the Cleveland meeting in 1887; and we further say that it is our opinion and belief that a suspended joint having all the qualities named in that report, and in addition to be from 28 to 30 in. in length and having six bolts, has all the essential features required for a standard track-joint, and herewith submit blue prints of a section and side elevation of what we hereby recommend for a standard track-joint."

The discussion on these reports, which was joined in by many members, showed the usual wide difference of opinion in relation to the rail-joint question. Many experiences were given, but the general result seemed to be that no roadmaster was satisfied with the joints in use on his road.

SECOND DAY.

At the morning session the discussion of the reports on rail-joints was resumed; after a short time it was closed by the passage of a resolution referring both reports back to the Committee, with instructions to present a new report at the next convention. Roadmasters are also requested to make comparative tests of the supported joint and the heavy suspended joint under similar conditions of track and traffic.

The Committee on Snow and Snow-Plows presented its report, recommending the use of an iron snow-plow for ordinary snowfalls and the Rotary plow for very heavy snow. The use of snow-fences at exposed points was also recommended.

The Committee on Cross-ties presented a report, recommending for ballasted track ties 7 by 8 in., 8 ft. long, and for mud ballast or unballasted roads ties 7 by 10 in., 9 ft. long, 11 ties to be used for a 30-ft. rail. No recommendation was made with regard to metal ties or to the methods of preserving timber. This report called out some discussion, the objection being raised that it was now difficult on many roads to get 7 by 10 in. ties.

At the afternoon session the Committee on Standard Hand-cars presented a report, giving weights and dimensions, but not recommending any special pattern. This was adopted.

The Committee on Standard Frogs submitted a report, a letter was also read from the Superintendents' Association asking for an expression of opinion as to the relative merits of solid and spring-rail frogs; after some discussion the subject was carried over to the next annual meeting.

Several members then stated their experience with different processes for the preservation of ties.

The Committee on Labor on Track presented a report, which was discussed and then referred back, the Committee being continued.

A memorial of Mr. Charles Latimer was presented. It was resolved to hold the next annual meeting at Denver.

The following officers were then elected: President, J. W. Craig, Charleston & Savannah; First Vice-President, I. Burnett, Joliet Steel Works; Second Vice President, James Sloan, Chicago & Eastern Illinois; Secretary and Treasurer, H. W. Reed, Savannah, Florida & Western; Executive Member for three years, R. Black, Manhattan Elevated.

OBITUARY.

COLONEL GEORGE W. PERKINS, the oldest railroad officer in the United States, a notice of whom was published in our last number, died at Groton, Conn., September 5. He was 100 years and one month old, and had been Treasurer of the Norwich & Worcester Railroad Company for over 50 years.

RICHARD A. PROCTOR, the well-known astronomer and popular writer and lecturer on astronomy, died in New York, September 12, of yellow fever. He was born in Chelsea, England, in 1837, graduated from Cambridge University in 1860, and early became known as a lecturer. He first visited this country in 1873; some years ago he decided to settle here, and established his home and observatory near Orange Lake, Fla. At the time of his death he was on his way from Florida to England.

PERSONALS.

W. R. MICHIE is now Assistant Engineer of the St. Louis & San Francisco Railroad.

J. H. PEARSON is now Engineer in charge of the Georgetown Extension of the Louisville Southern Railroad.

J. J. TOMLINSON is now Master Mechanic of the Gulf, Colorado & Santa Fé Railroad, with office in Galveston, Tex.

F. L. PITMAN has been appointed Chief Engineer of the Atlantic & Danville Railroad, succeeding George S. Bruce, resigned.

JACOB JOHANN, late Superintendent of Motive Power of the Texas & Pacific Railroad, is at present residing in Springfield, Ill., his former home.

V. O. CASSELL has been appointed Assistant Engineer of the Atlantic & Danville Railroad, succeeding F. L. Pitman, who is now Chief Engineer.

GEORGE R. OTT has been appointed Master Mechanic of the Chicago Division of the Baltimore & Ohio Railroad, succeeding B. F. LOWTHER, who has resigned.

G. W. CUSHING, late Superintendent of Motive Power of the Philadelphia & Reading Railroad, has changed his address from Reading, Pa., to Box 278, Chicago, Ill.

J. EVANS has been appointed Master Mechanic of the Oregon Railway & Navigation Company, with headquarters at Dalles, Ore., succeeding H. Webber, resigned.

T. W. HEINTZELMAN has been appointed Assistant Superintendent of Motive Power of the Southern Pacific Company, with office in Sacramento, Cal.

GEORGE S. BRUCE, late Chief Engineer of the Atlantic & Danville Railroad, has resigned that position and has become a member of the new firm of Harper, Bruce & Co., engineers and contractors.

EDWARD D. BOLTON, C.E., of the firm of T. William Harris & Co., of New York, has been appointed Consulting Engineer for Asheville, N. C., in connection with the new sewerage system, upon which it is proposed to expend $100,000. JOHN G. ASTON, City Engineer, will be Resident Engineer.

COLONEL T. M. R. TALCOTT has resigned the office of Commissioner of the Southern Railway & Steamship Association, to accept the position of First Vice-President of the Richmond & Danville Railroad. He is thoroughly familiar with that road, having been formerly connected with it for 16 years as Chief Engineer, Superintendent, and General Manager.

LIEUTENANT JACOB J. HUNKER has been designated by the President under the new law as Supervisor of the Harbor of New York. He is to act under the direction of the Secretary of War in enforcing the provisions of the act to prevent obstruction and injurious deposits within the harbor and adjacent waters of New York City by dumping or otherwise, and he is to detect all offenders against this act. He is to direct the patrol boats and other means to detect and bring to punishment offenders against the provisions of the act.

EZRA M. REED has resigned his position as Vice-President of the New York, New Haven & Hartford Railroad Company, and will retire from active work altogether. Mr. Reed entered the service of the Hartford & New Haven Company in 1843, and served as Master Mechanic and Superintendent of that road. After the consolidation by which the present company was formed he was made General Superintendent of the road, and some years later Vice-President also.

NOTES AND NEWS.

New White Star Steamers.—The White Star Line is having two new ships built at Harland & Wolf's shipyard at Belfast. One of them is named the *Majestic*, but the name of the other has not yet been made known. The length on the water line is 565 ft. and the width 52 ft. The vessels are to be propelled by twin screws, which overlap at the tips, the starboard screw being carried some feet further aft to get clearance.

Proposals for Submarine Torpedo Boat.—The Navy Department has decided to readvertise for contracts for the proposed submarine torpedo boat. The proposals will be received by the Department until January 4, 1889. The contractor must furnish a boat complete with torpedo fittings and appendages; it must be built of steel, of material manufactured in the United States, and must be of the best modern design. The proposals must be accompanied by drawings and specifications showing clearly what he proposes to build. Information for the general requirements to be made in the plans can be obtained on application to the Bureau of Ordnance Department.

Baltimore & Ohio Mechanical Reorganization.—In connection with the general reorganization of the Baltimore & Ohio management, President Spencer has appointed a Commission to examine thoroughly the shops, stationary machinery, and motive power of the road, and to report what reforms and improvements are needed in order to bring the machinery up to modern requirements, and to secure the best division of labor and concentration of work. The Commission will visit all the shops of the company, and also those of several other leading companies. At the head of the Commission is Mr. M. N. Forney, of New York, the other members being all officers of the company, as follows: A. J. Cromwell, Superintendent Motive Power of the Lines East of the Ohio River; J. N. Kalbaugh, Master of Machinery, Pittsburgh Division, and E. L. Weisgerber, Master of Machinery of the Ohio Division.

An Individual Heater.—An exchange says that a portable steam heater has recently been invented by a Bridgeport man, consisting of a copper boiler, under which is a diminutive lamp, encased in a nickel box, and balanced something like a compass, so that, no matter what position the outside box is in, the boiler and lamp will always remain in the required vertical position. After the lamp is lighted, the water in the boiler is heated and circulated through rubber tubes, which run down the legs, around the ankles, up around the back, and back to the boiler. The circulation of the water keeps the body warm on the coldest day. Elaborate heaters are being constructed for ladies' wear, which can be worn inside the bustle and gauged so as to run eight or ten hours. A safety-valve is provided to prevent excessive pressure.

It cannot be denied that this apparatus promises comfort to cold-blooded people, but there are contingencies to be taken into account. To say nothing of the picturesque spectacle which a man would present with steam blowing off from the back of his neck, or a lady with the valve in her—well, bustle—in full blast, the contingency of a possible explosion must be taken into account, should the aforesaid safety-valve stick. Then, too, the apparatus might be comfortable in a car, but too much pressure, and the consequent escape of steam, might produce that high degree of humidity which we all dread in late summer; while in a collision it might be an open question whether 50 simultaneous little explosions might not do as much damage as one large one. As a compensation, however, lovers will urge that any suspicious sound heard while passing through a tunnel could be easily explained as the pop of a safety-valve, and ill-natured criticism thus prevented.

Russian Petroleum in Sweden.—Consul Ernest A. Man writes to the State Department from Gothenburg, Sweden, as follows:

" Russian petroleum is being advertised and introduced very

extensively in the market here. For some time past there have appeared daily in the newspapers advertisements in large type, offering Russian petroleum at retail at 29 öre ($0.077) per kanna (0.6915 gallons), and American petroleum at 35 öre ($0.093) per kanna, with the apparent object of attracting general attention to the lower price of the Russian oil. This makes a difference of but 6 öre or ($0.016) a kanna in favor of the Russian product, which amount, when reduced to United States currency, seems very small; but in Sweden the difference of 6 öre in purchasing a trifle over ⅔ gallon of oil would have as much, if not considerably more, influence on a buyer than a difference of 6 *cents* on a similar quantity would have in the United States.

"A storage tank of a capacity of 12,000 barrels has recently been erected on one of the small islands in the harbor below the city, and a tank steamer from Libau, Russia, has just brought and discharged a cargo of 7,000 barrels, and is now returning to Libau for a second lading. This is the first importation ever brought into this port in the above manner. This oil will be distributed through the medium of barrels collected in this locality, most of which are of American manufacture, to the obvious disadvantage of our petroleum interest. I am convinced that much of the strong-smelling oil that is already sold here as American oil never crossed the Atlantic. Although the difference in price between the two oils is slight, it would still prove a strong factor in driving the American oil—notwithstanding its acknowledged superiority—from the Swedish market, as there is probably no other country in Europe where economy is more rigidly practised or is more necessary. In this high latitude the expense of illuminating, instead of being distributed, as elsewhere, with comparative equality throughout the year, is condensed into six or seven months, when the other needs of a rigorous winter season fall with an accumulated volume upon the people."

Railroads of Southern Brazil.—At present there are three railroads in operation in the Province of Rio Grande do Sul, projected for which preliminary surveys have been made.

The lines in operation are the Rio Grande & Bage, opened for traffic on December 2, 1884; the Porto Alegre & Uruguayana, opened March, 1883, and the Porto Alegre & Novo Hamburgo, opened in 1875.

The Rio Grande & Bage road is substantially built; has a gauge of 1 meter, or 1.09 yards, and is laid with heavy T-rails, of English manufacture, on hard-wood sleepers, secured with spikes, and ends joined with fish-plates and bolts. It was built and is at present owned and operated by an English company. The locomotives are from the Baldwin Locomotive Works, of Philadelphia, of the Mogul pattern, burning Cardiff coal and patent fuel, which is simply very fine coal mixed with some resinous substance and pressed into hard blocks. Passenger coaches are of two classes. Those for the first-class passengers were made in the United States and on the American plan, and those for the second-class passengers were made in Europe, but on the same plan as the first-class coaches. The traffic, or freight cars are of Brazilian make, being light and short, mounted on a single truck at each end. It is expected to extend this road to the Brazilian boundary line.

The latest pubished official returns showing the receipts and expenses of the road, are for the year 1886, $329,645, and expenses, including improvements, $306,364, leaving an unexpended balance of $23,281.

The second road, when completed, will run from Porto Alegre, the capital of the province, in the central eastern part, to Uruguayana, on the Uruguay River, a distance of 378 miles. However, it is not completed over two-thirds of the way, the work of track-laying progressing slowly.

The third and last line in operation is a short one, 26 miles in length, connecting the capital with New Hamburg, a large German settlement. It is owned by an English company.

There is constant communication from Rio Grande do Sul to Rio de Janeiro by several steamship lines.

French Steam Navigation.—The directors of the French General Transatlantic Company have introduced a system of premiums or awards for economies realized in working expenses. The result has been that the company has secured appreciable reductions in respect of the cost of motive power, maintenance of ships, stores, etc. Careful attention has also been directed to what is styled the "Manutention service," so as to reduce the cost of labor and the outlay for tugs, lighters, etc. Every effort has been made to obtain the largest amount of work and service out of steamers comprising the company's fleet, and last year the 65 vessels of the fleet list made 1,206 voyages in the Atlantic and the Mediterranean, the aggregate distance traversed being 775,168 marine leagues. In this total the company's postal service figured for 487,694 marine leagues, and what are known as the "free services" of the company for 287,474 marine leagues. Careful attention has been given to obtaining stores and supplies of all kinds upon the cheapest possible terms; the importance of this will be seen in the fact that the outlay made under this head amounted last year to $3,060,000. In the course of last year the company's works at Penhoet completed the transformation of the steamer *La Fazette*, the old engines and boilers in this vessel being replaced by altogether new and more powerful high-pressure and triple-expansion engines, which have enabled the ship to attain a speed of 14 knots per hour. *La Fazette* was supplied last year with electric lighting apparatus, while her fittings were also materially improved. A similar policy is being pursued this year with the *St. Laurent* and the *Labrador*, so that the company's West Indian line will soon be in a thoroughly efficient state. New boilers are about to be supplied to the company's Mediterranean steamers, which will also be otherwise improved. The efficiency of the Mediterranean fleet will be further increased by two powerful steamers, the *Eugene Pereire* and the *Maréchal Bugeaud*, being placed upon the line. Bronze screws are being supplied to several of the company's steamers which are required to attain high rates of speed. The forced draft has also been introduced into some of the company's ships, but this is being done cautiously, as sundry complex questions have to be considered in connection with it. Not only have the company's works at Penhoet been highly useful in maintaining the efficiency and providing for the renewal and improvement of the company's fleet, but they also did some work last year for the French Admiralty, to which the company recently delivered the *Girafe*, while it is now engaged on a swift cruiser to be named the *Cootlogon*. At the present time the company is employing 1,800 persons at Penhoet.—*London Engineering.*

Natural Gas in China.—Consul Denby writes from Peking to the State Department as follows: "The following abstract of an account given by Baron von Richtofen of natural gas wells in China may be interesting. These wells are found in Sz'chwan, near a town called Tsz-lin-tsing. In an area of 27 li (9 miles) diameter salt wells are found. To make a well the Chinese use a long and elastic bamboo pole, supported in the middle by a cross piece, a rope made by coupling the ends of long (not twisted) slices of bamboo, and an iron instrument which weighs 120 catties (catty=1⅓ lbs.). The rope is fastened on the thin end of the pole, and the iron on the end of the rope. A slight up and down motion of the thick end of the pole makes the iron hop and bore a vertical hoe with its broad, sharpened edge. The ground to be perforated consists chiefly of sandstone and clay. When a portion of the rock is mashed, clear water is poured into the hole, a long bamboo tube with a valve in the bottom is lowered, and the turbid water raised to the top. Pipes of cypress wood are rammed in to protect the sides of the bored hole and to prevent the water contained in the surrounding ground from getting access to the well; the pipes are attached to each other at the ends with nails, hemp, and tung oil. The inner width of the pipes is about 5 in. As the work proceeds the pipes are rammed deeper, and a new one attached on the top; the rope, too, is made longer. At a depth varying from 70 to 100 chang (700 to 1,000 ft.) the brine is struck, and the well is fit for use. The brine is raised to the top through long bamboo tubes and bamboo ropes, as described, by means of a horse-whim, and then carried to large pans for evaporation, or led to them through bamboo pipes.

"Besides these wells there are others, which are bored to the depth of from 1,800 to 2,000 ft. At that distance below the surface petroleum is struck. Immediately on reaching it an inflammatory gas escapes with great violence. Work is now stopped, and a wooden cap fastened over the mouth of the pit, perforated by several rows of round holes. In each of them a bamboo pipe is inserted, and through these the gas is led under the evaporation pans. The pipes ramify, and on each end a tapering mouthpiece, terminating in a small aperture, is attached. The gas is then used for evaporating the brine.

"The enterprising spirit which induced the Chinese to examine the ground at so great a depth is said to have had its origin in the drying up of a brine pit. The proprietor was in hopes of meeting brine at a greater depth, but found instead the gas.

"When the country was infested with rebels during the Taiping rebellion they removed the cap from one of the gas pits and set fire to it. Since that time, or at least up to the time that Baron Richtofen wrote, a long column of fire rose from that pit, and it is considered nearly impossible to stop the flame.

"The gas pits and brine pits are owned separately by corporations. The owners are subjected to the control of the Government. The Government monopoly is in the hands of the 'Taotai,' who resides at the place. The salt works of Tsi-lin-tsing yield considerable revenue to the Government, and have besides enriched numerous proprietors, and given occupation to a numerous population. The number of 'fire pits' is 24, and

the salt pits are innumerable. Some of them do not enjoy the advantages of gas. The brine is evaporated with grass and wood.

"There are salt pits in neighboring localities on the Min River, but no gas pits."

Electric Purification of Sewage.—A patent has recently been granted W. Webster for a system of electric purification of sewage which covers also a similar system of purifying drinking water as well as the waste or sewage water. The Metropolitan Board of Works in London, which is now establishing, at an expense of $5,000,000, a plant for the chemical treatment of sewage, has given Mr. Webster permission to make, at his own expense and under the direction of the officers of the Board, a trial of his invention on a practical scale. The inventor proposes to treat 1,125 cubic meters of sewage per day, running six days a week, and to continue this for a sufficiently long time to establish the merits of his system.

The full particulars of his plan have not been published, but the inventor proposes, instead of placing chemical products in the water to be purified, to form these products from the sewage matter itself by means of an electric current generated by dynamos placed in the work-shops, and by agitating this matter by means of electrodes placed within it.

It seems that the reaction in this case is very curious; instead of being precipitated to the bottom of the purifying tank, as in the case of simple chemical treatment, the impurities mount to the surface, carried up by the gas bubbles originating from the electric current. They can then be skimmed off or can be made to fall back to the bottom by stirring up the tank, the latter operation freeing the solid impurities from the bubbles of gas which were attached to them. It is claimed that this process has the advantages that it is inodorous, that it is continuous, that nothing is added to the weight of the matter to be taken out of the tank, and that it preserves in the impurities a large part of the ammonia, which is very profitable in case these impurities are utilized as manure.

The annual expense of the electric purification of the entire volume of sewage of London is estimated at $125,000. According to the plan of the Board of Works, now in course of execution, the annual expense of the chemical treatment would be $150,000, of which $90,000 would be expended for iron and lime and $60,000 for permanganic acid.

The economy of the electric process would not stop with this first cost, however, because the amount of solid matter to be transported per day would be only 10 tons against 45 tons with the chemical process. These quantities are naturally increased by the proportion of water in which they are found in solution under the form of sediments; the difference is therefore considerable in favor of the electric process.

This chemical plant which the Board of Works is now preparing is not due alone to the progress of ideas on this point, but is really an imperative necessity in order to put a stop to the poisoning of the waters of the Thames. The people on the banks of that river have been for a long time complaining with much reason, and have at last taken legal measures to compel the authorities to put a stop to it.—*M. Berla, in Annales des Ponts et Chaussées.*

Proposed New Patent Court.—Judge Culberson, the chairman of the House Judiciary Committee, has submitted his report in favor of the bill to establish a Court of Patent Appeals. This Court, as provided for by the bill and amendments reported by the Committee, consists of one chief-justice and two associate justices, who shall be appointed by the President, by and with the advice and consent of the Senate, and who shall hold office during good behavior, and receive a salary each of $6,000 per annum.

The Court is required to hold one term annually at the seat of Government, commencing on the second Monday in October, and may hold special or adjourned terms, as the Court may deem proper, for the despatch of business.

Judge Culberson says that among the results reasonably expected to flow from the organization of a Court of Patent Appeals attention may be called to the following:

1. It would enable the public and patentees to determine the value and validity of patents without serious and vexatious delays, and thus promote the interests of all concerned.

2. It will relieve the Supreme Court of much of the burden imposed upon it by this class of litigation.

3. The practice in the Patent Office would become thoroughly fixed and understood, and, as a consequence, the issue of worthless patents, in which unscrupulous persons deal to the injury of the public, would be greatly diminished, if not entirely suppressed.

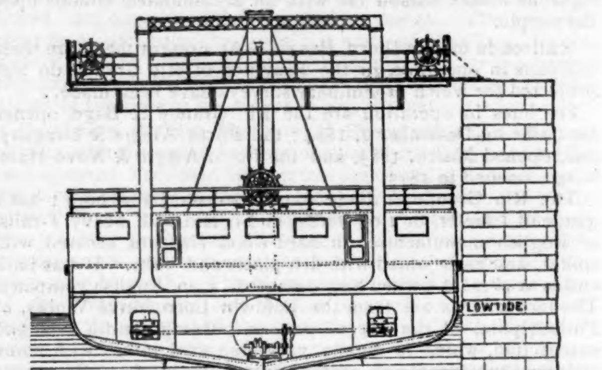
4. It would tend to simplify the patent laws by constriction, and to settle questions of doubt which are often used by litigants for the purpose of injustice and oppression.

Without intending to present the reasons at length which induce the Committee to arrive at the foregoing conclusions, the following observations are submitted: The life of a patent at most is 17 years, and if it is a valuable one or intricate and radical, it usually requires one-fourth of that period to introduce it and secure its use by the public.

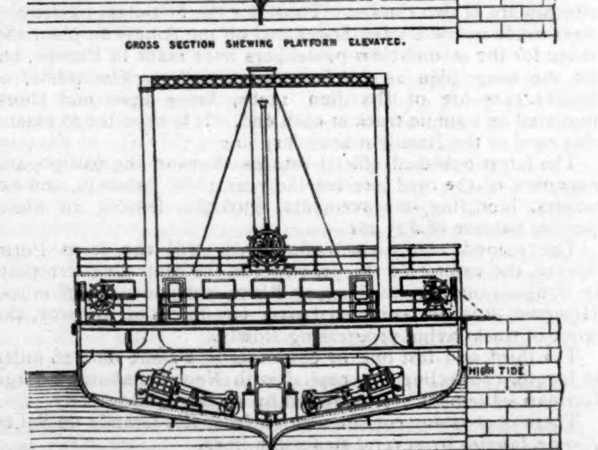
Under the present condition of the business of the courts it requires, ordinarily, from two to three years to obtain a decision in the Circuit Court of the United States, and if appealed to the Supreme Court from three to four years are required to obtain a decision. It may be said that the same difficulty and delay attend the determination of all other questions involving the determination of property rights. While this is true, it should be borne in mind that this species or character of property differs from all other kinds of property. The duration of the owner's title is arbitrarily fixed by law.

The bill provides that the new Court shall make a finding both of facts and of law, and that appeals to the Supreme Court shall be taken on questions of law only, thus very much simplifying the cases and making it possible to secure final decisions in a reasonable time.

An Elevating Ferry Steamer.—The accompanying illustrations, from the London *Engineer*, show a peculiar steam ferry-boat, designed for the River Clyde at Glasgow by W. Simons & Company, ship-builders, at Renfrew, Scotland. In this case, instead of providing movable landing stages to meet the rise and fall of the tide, the deck of the ferry-boat itself is a movable platform carried on six hydraulic elevators, by which it can be raised or depressed as required. The boat itself is a double-ender 150 ft. long, 55 ft. extreme breadth, 17 ft. 6 in. depth of



CROSS SECTION SHEWING PLATFORM ELEVATED.



CROSS SECTION SHEWING PLATFORM LOWERED.

hull, and having a draft of water of 12 ft. 6 in. It is driven by twin screws, propelled by two sets of triple-expansion engines of the ordinary type. Each end of the boat is provided with twin screws and a rudder, and the engines can be coupled to either end as desired. On each end of the main deck a cabin is provided, and the entire space between these cabins is filled up by the movable deck, which has a rise of 25 ft. altogether. The landing is made at the side. The illustrations show cross-sections of the boat with the deck lowered for high tide and raised for low tide. A slight modification of the present design would adapt the boat equally well for an end landing, and, in fact, the plan permits of almost any change to suit local circumstances.